South Saskatchewan River Sub-Basin Contributions To International and Interprovincial Water-Sharing Agreements

Prepared for:

South Saskatchewan River Basin
Water Management Plan Steering Committee

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EXECUTIVE SUMMARY

The South Saskatchewan River, immediately downstream of the Alberta-Saskatchewan boundary, receives water from four major sub-basin areas: the Red Deer, Bow, Oldman, and the Lower South Saskatchewan River sub-basins. The headwaters of the Red Deer and Bow Rivers are located entirely in the Alberta portion of the eastern face of the Rocky Mountains, while the Oldman River receives flow from the Waterton, Belly, and St. Mary Rivers, which have their headwaters in Montana.

The International and Interprovincial sharing of waters of the South Saskatchewan River is governed by two agreements, the 1909 Boundary Waters Treaty between Great Britain and the United States of America (as stipulated by the 1921 Order of the International Joint Commission - IJC), which outlines the division of international streams, including the waters of the St. Mary River, and the 1969 Master Agreement On Apportionment which outlines the division of waters between Alberta and Saskatchewan of eastward flowing interprovincial streams, including the South Saskatchewan River. This report examined the interpretation that has been applied to the 1909 Boundary Waters Treaty by the International Joint Commission and the interpretation that has been applied to the 1969 Master Agreement On Apportionment by the Prairie Provinces Water Board so as to provide clarity on these Agreements.

This report examined the recorded and naturalized flows throughout the system to evaluate the relative contribution of each of the sub-basins to the water-sharing agreements and to identify potential trends in their relative contributions.

The report also examined the recorded and naturalized flows of the St. Mary River, Oldman River, Bow River, Red Deer River, and the South Saskatchewan River to evaluate the relative contribution of the four sub-basins to the natural and Apportionment flow of the South Saskatchewan River below the Red Deer River confluence and to identify potential trends in their relative contribution. The analysis is limited to the 1975 to 1995 period or the last 21 years for which natural flow computations are available for all sub-basins.

The findings of this report are summarized as follows:

1. During the 1975 to 1995 period the South Saskatchewan River at the confluence with the Red Deer River had a mean annual flow of 8,399,000 dam^3. The mean annual flow is comprised of 1,507,000 dam^3 (17.9%) originating in the Red Deer basin, 3,665,000 dam^3 (43.6%) originating in the Bow basin, 3,191,000 dam^3 (38%) originating in the Oldman basin, and about 36,500 dam^3 (0.4%) that originate in the Lower South Saskatchewan basin.
2. The South Saskatchewan River and its tributaries are subject to two water-sharing agreements, the 1909 Boundary Waters Treaty which, during the April 1 to October 31 irrigation season, entitles the U.S to 25% of the flow in the St. Mary River for flows less than 666 cfs and to 50% of the flow in excess of 666 cubic feet per second, and the 1969 Master Agreement On Apportionment which entitles Saskatchewan to approximately 50% of the "apportionable" flow (natural less U.S. diversions) of the South Saskatchewan River below the confluence with the Red Deer River.

3. Under the 1909 Boundary Treaty, the U.S. has diverted a mean annual volume of 210,000 dam^3 from the St. Mary River, or 7.3% of the natural flow of the Oldman River basin. During dry years, the U.S. diversions are in the order of 10% to 12% of the natural flow of the Oldman River basin. The U.S. diversions are currently less than the U.S. entitlements and will increase if the U.S. implements improvements to their storage and/or diversion infrastructure.

4. During the 21-year period analyzed, Alberta, on average, has passed 75.5% of the apportionable flow to Saskatchewan rather than the 50% required under the Master Agreement on Apportionment. This represents a mean annual surplus delivery to Saskatchewan of about 2,246,000 dam^3. Even during extremely dry years, Alberta has had surplus deliveries that are greater than 400,000 dam^3. As such, the large percentage of the natural flow of the Red Deer River delivered to Saskatchewan appears to be due to the non-consumption and lack of major storage devices in the basin rather than due to policy requirements. This surplus delivery will be marginally reduced if current accounting procedures are modified to include minor diversions in Alberta. These surplus deliveries may increase further during extremely dry years as a result of recently implemented minimum flow requirements for the South Saskatchewan River through Medicine Hat as well as other reaches throughout the system.

5. The Red Deer basin has a mean annual flow of about 1,507,000 dam^3. This has varied from a low of about 794,000 dam^3 (52.8% of average) to a high of 2,664,000 dam^3 (177% of average). Under current apportionment computation procedures, the Red Deer basin passes a relatively constant 98.4% of the mean annual natural flow to Saskatchewan.

6. The Bow basin has a mean annual flow of about 3,665,000 dam^3. This has varied from a low of about 2,643,000 dam^3 (72.1% of average) to a high of 4,897,000 (133% of average), or a significantly less variable supply than either the Red Deer or the Oldman basin. Under current apportionment computation procedures, the Bow basin has passed an average of about 72.5% of the mean annual natural flow to Saskatchewan. This percentage has varied from a low of 57.5% in 1984 and 1988 to a high of 86.2% in 1975 and 1994.

7. The Oldman basin has a mean annual flow of about 3,191,000 dam^3. This has varied from a low of about 1,544,000 dam^3 (48.4% of average) to a high of 6,502,000 dam^3 (204% of average), as such it has a significantly more variable supply than the Red Deer or the Bow basin. Under current apportionment computation procedures, the Oldman River has passed an average of about 68.7% of its mean annual "apportionable" flow to Saskatchewan. This percentage has varied from a low of 41.2% in 1988 to a high of 91.8% in 1975. In addition to the 1969 Master Agreement, the flows of the St. Mary River, a major tributary of the Oldman River, are also subject to water-sharing under the 1909 Boundary Waters Treaty. Under this agreement, the U.S. has diverted a mean annual volume of about 210,000 dam^3, 7.3% of the natural flow of the Oldman basin. This diversion could increase if the U.S. implements improvements to its storage facilities or diversion canal. On average, the Oldman basin contributes 71.3 % of its natural flow towards meeting the requirements of the two water-sharing agreements. This percentage has varied from a low of 47.9% in 1988, a year in which natural flow was only 57% of average, to a high of 92% in 1975.

8. Development within the Red Deer basin, during the 1975 to 1995 period, was not constrained by it being required to contribute a disproportionate volume of its natural flow to apportionment to offset consumption in the Bow and/or Oldman basins. However,

it is noted that during this period the irrigation districts, which derive their irrigation requirements from the Bow and Oldman, were not utilizing their full allocations. As such, the situation may change in the future if irrigation districts move towards a higher level of utilization by increasing diversions and/or reducing return flows.

RECOMMENDATIONS

On the basis of the foregoing analysis the report recommends the following:

1. That a review be conducted to assess the relative impact and tradeoffs of fixed versus variable instream flows, which are linked to natural flow, for the South Saskatchewan River through Medicine Hat as well as other reaches throughout the system.

   Article 4A of the 1969 Master Agreement on Apportionment recognized prior allocations in Alberta by stating "Alberta shall be entitled in each year to consume, or to divert or store for its consumptive use a minimum of 2,100,000 acre-feet net depletion out of the flow of the watercourse known as the South Saskatchewan River even though its share for the said year ... would be less than 2,100,000 acre-feet net depletion, provided however Alberta shall not be entitled to so consume or divert or store for its consumptive use, more than one-half the natural flow ... if the effect thereof at any time would be to reduce the actual flow ... at the common boundary ... to less than 1500 cubic feet per second." Recently implemented minimum flow requirements for the South Saskatchewan River through Medicine Hat as well as other reaches throughout the system however may preclude Alberta's ability to make full use of its entitlements under this clause. As such, the relative impact of instream flows on Alberta's ability to utilize its share of the water of the South Saskatchewan River needs to be assessed.

2. The implementation of a policy that would require each sub-basin to contribute 50% of apportionable flow to apportionment each and every year is not recommended.

   During many years, all three sub-basins exhibited similar conditions in terms of above, below or near average conditions, although of differing magnitudes. However, in about 38% of the years (1975, 1976, 1978, 1982, 1986, 1989, 1992, and 1994) the three basins experienced different conditions, in that one or two sub-basins experienced near average or above average conditions while the other(s) experienced below average conditions.

   The 1969 Master Agreement on Apportionment intentionally established the South Saskatchewan River below the confluence with the Red Deer River as the point for apportionment, even though this site is in Saskatchewan. This point was selected as the point for apportionment so as to permit Alberta to meet Saskatchewan's entitlements using any combination of flow from the three sub-basins it desired, thereby providing Alberta with added flexibility in managing its share of the flow of the South Saskatchewan River. If Alberta were to implement a policy that would require each sub-basin to contribute 50% of its annual flow to apportionment, regardless of sub-basin conditions, Alberta's water management flexibility would be significantly compromised and in fact could create a situation in which large surplus deliveries are being made to Saskatchewan while one or more of the sub-basins are experiencing a severe shortage.

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South Saskatchewan River Basin

Sub-Basin Contributions to International and Interprovincial Water-Sharing Agreements

1 INTRODUCTION

The South Saskatchewan River, immediately downstream of the Alberta-Saskatchewan boundary, receives water from four major sub-basin areas: the Red Deer, Bow, Oldman, and Lower South Saskatchewan River sub-basins (Figure 1). The headwaters of the Red Deer and Bow Rivers are located entirely in the Alberta portion of the eastern face of the Rocky Mountains, while the Oldman River receives flow from the Waterton, Belly, and St. Mary Rivers, which have their headwaters in Montana.

Figure 1. South Saskatchewan River sub-basins.

The sharing of waters of the South Saskatchewan River is governed by the 1909 Boundary Waters Treaty between Great Britain and the United States of America (as stipulated by the 1921 Order of the International Joint Commission - IJC) which outlines the division of waters of the St. Mary River, and by the 1969 Master Agreement On Apportionment which outlines the division of waters between Alberta and Saskatchewan of eastward flowing interprovincial streams, including the South Saskatchewan River.

The measurement and division of the waters of the St. Mary River is carried out by the Reclamation Officer of the United States and the Irrigation Officer of Canada under the direction of the IJC. Computations are reviewed by Alberta and Montana prior to finalization.

The Prairie Provinces Water Board (PPWB) carries out the administration of the Master Agreement. The PPWB's Committee on Hydrology, which includes a member from Alberta, reviews the apportionment computations prior to finalization.

Both computational procedures utilize a number of rules and guidelines and a large number of monitoring sites to facilitate the computation of natural flows and to ensure that the water-sharing agreements are being adhered to.

This report examines the recorded and naturalized flows of the St. Mary River, Oldman River, Bow River, Red Deer River, and the South Saskatchewan River to evaluate the relative contribution of the various sub-basins to Apportionment. The evaluation begins by examining the 1909 Boundary Waters Treaty and the 1969 Master Agreement On Apportionment as they relate to the South Saskatchewan River. It then examines the recorded flow, the natural flow, and the contribution to apportionment for each of the South Saskatchewan River sub-basins. The analysis is limited to the 1975 to 1995 period or the last 21 years for which natural flow computations are available for all sub-basins.

2 1909 BOUNDARY WATERS TREATY

The St. Mary River originates in northwestern Montana, on the eastern slopes of the Rocky Mountains, and flows north across the International Boundary in Alberta, emptying into the Oldman River near Lethbridge. The St. Mary River has a fairly regular and dependable flow during the summer period because of its source in the high elevation snowfields and glaciers of Glacier National Park. Ground water flow sustains winter flows.

The waters of the St Mary River are divided between Canada and the United States in accordance with the October 1921 Order of the IJC. In general terms, Rule I states, "During the irrigation season (April 1 to October 31), Canada shall be entitled to three-fourths of the natural flow at the International Boundary when the natural flow is 666 cubic feet per second (cfs) or less and flows in excess of 666 cfs (18.9 m^3/s) shall be divided equally between the two countries. During the non-irrigation season, the natural flow at the international Boundary shall be divided equally between the two countries."

To ensure that the Order is followed, provisional computations are made on a daily basis and interim reports are prepared twice monthly whenever the U.S. is making diversions from the St. Mary River via the U.S. St. Mary canal. As this Agreement is based on the apportionment of daily flows, with two balancing periods per month, excess deliveries by the U.S. cannot be banked or applied against future delivery shortfalls while deficit deliveries are carried forward and are to be paid back in the next balancing period.

3 1969 MASTER AGREEMENT ON APPORTIONMENT

3.1 Pertinent Clauses

The 1969 Master Agreement On Apportionment divides the waters of eastward flowing interprovincial watercourses equitably between Alberta and Saskatchewan. The general principle of the Agreement, outlined in Article 3, Schedule A, is that; "Alberta shall permit a quantity of water equal to one-half of the natural flow [less U.S.A. diversions] of each watercourse to flow into the Province of Saskatchewan ...".

In the case of the South Saskatchewan River, the Agreement listed a number of additional conditions. These are:

1. Article 2C, which states; "... the point at which the natural flow of the watercourses known as the South Saskatchewan and Red Deer Rivers is to be determined may be, at the option of Alberta, at a point at or as near as reasonably may be below the confluence of the said two rivers."
2. Article 4A, which states; "Alberta shall be entitled in each year to consume, or to divert or store for its consumptive use a minimum of 2,100,000 acre-feet net depletion out of the flow of the watercourse known as the South Saskatchewan River even though its share for the said year ... would be less than 2,100,000 acre-feet net depletion, provided however Alberta shall not be entitled to so consume or divert or store for its consumptive use, more than one-half the natural flow ... if the effect thereof at any time would be to reduce the actual flow ... at the common boundary ... to less than 1500 cubic feet per second."
3. Article 4B, which states; "The consumption or diversion by Alberta provided for under the preceding subparagraph shall be made equitably during each year, depending on the actual flow of water in the said watercourse and the requirements of each Province, from time to time".

3.2 Interpretation of Pertinent Clauses

As the interpretation of these conditions can have a significant influence on the Administration of the Master Agreement, a brief description as to how these special provisions have been applied to the South Saskatchewan River in past years is provided.

a) Article 2C, in the past has been interpreted to imply that the waters of the South Saskatchewan and Red Deer Rivers, for apportionment purposes, may be treated as a single entity. That is, Alberta's delivery of Saskatchewan's entitlements during a particular year may be made entirely from the Red Deer River or entirely from the South Saskatchewan River, or any combination thereof, at the discretion of Alberta.

b) Article 4A contains two conditions, one on the minimum flow rate and another on the annual volume. The interpretations of these conditions was provided by A. J. Chen and B. Goodwin in their paper, "Interprovincial Water Management In Drought Periods", which was presented at the 1986 Canadian Hydrology Symposium in Regina.

Within that paper the minimum flow rate condition is described as follows:

"When natural flow [less U.S.A. diversions] of the South Saskatchewan River at the boundary is greater than 85 m^3/s (3,000 cfs), minimum flow is to be 42.5 m^3/s (1,500 cfs). When natural flow at the boundary is less than 85 m^3/s (3,000 cfs) minimum flow would be one-half of the natural flow at the boundary." Figure 2, adopted from the above noted paper, illustrates the minimum flow requirement of this provision.

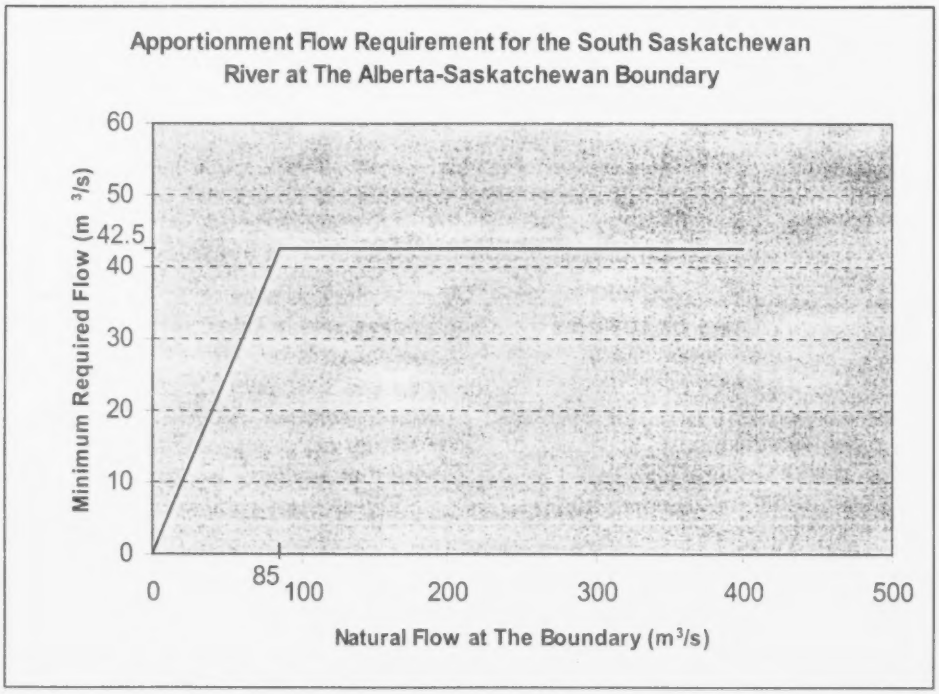

Figure 2. Apportionment flow requirements for the South Saskatchewan River.

The volume provision in Article 4A, also discussed in the paper, permits Alberta to store or consume a minimum of 2,100,000 acre-feet (2,590,000 dam^3) of water, even though this may be more than 50% of the annual volume, provided that the minimum flow constraint is satisfied. Figure 3, adopted from the paper, illustrates the distribution of annual flows for a condition where the flow rate is uniform (constant) throughout the year.

c) Article 4B, which states that, "The consumption or diversion by Alberta provided under the proceeding sub-paragraph shall be made equitably each year ... " is quite vague on the meaning of "equitable" although the phrase "... equitable each year ..." could imply that the calendar year is the balancing period, in the past the term has been used to imply that fair and reasonable steps were taken by Alberta to fulfill its obligations.

A more detailed interpretation of Alberta's entitlements of the apportionable flow of the South Saskatchewan River is provided in Appendix A.

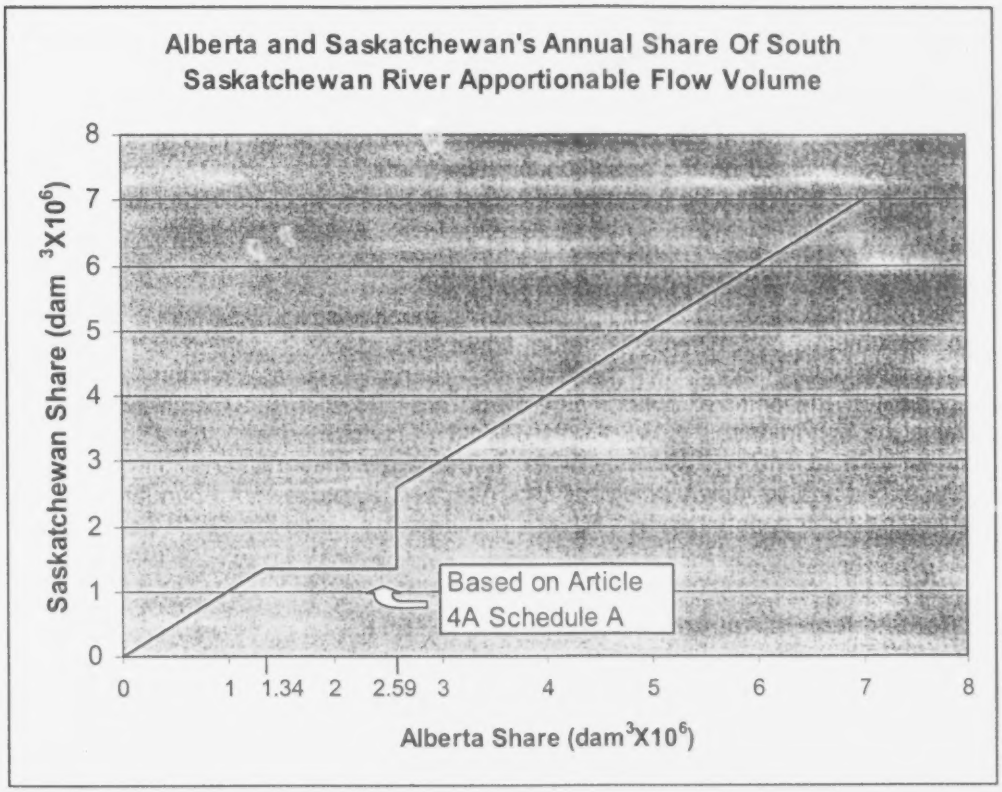

Figure 3. Alberta's and Saskatchewan's annual share of apportionable flow volume.

4 COMPUTATION OF APPORTIONMENT FLOWS

Adherence to the 1969 Master Agreement on Apportionment is monitored by the Secretariat of the PPWB based on quarterly audit reports. The auditing period reverts to one-month or less when the recorded flow at the point of apportionment drops below 42.5 m^3/s. The auditing of apportionment is based on the apportionable flow (natural flow less U.S. diversions), which is computed by the PPWB using a procedure known as the Project Depletion Method.

4.1 Project Depletion Method

The Project Depletion Method starts by calculating monthly streamflow depletions (adjustments) due to consumptive use, diversions, return flows, and reservoir storage and evaporation from major, quantifiable, man made projects in Alberta. The adjustments are then routed (transported) to the point of apportionment and are added to the monthly-recorded flows to determine the apportionable flow. As the PPWB is concerned with the Administration of the Master Agreement and not with how water is managed within Alberta, the PPWB computes monthly apportionable flows solely at the Alberta-Saskatchewan Boundary and does not determine the water contributed by each of the sub-basins within the South Saskatchewan River Basin.

4.2 Computation of Apportionable Flows

As indicated in the previous section, the current procedures compute the apportionable flow by adding the depletions due to consumptive use, diversions, return flows, and reservoir storage and evaporation from major, quantifiable, man made projects in Alberta. The computation of the apportionment flow requires the use of approximately 55 streamflow and lake/reservoir level stations used to quantify the flow and the adjustments. Table 1 provides a list of the man-made projects currently included in the computation of apportionable flow.

The apportionment flow computations do not include the U.S Diversions from the St. Mary River (which has been diverted and therefore is not part of the apportionable flow), municipal uses such as for the Cities of Calgary, Lethbridge, Red Deer, Medicine Hat and Drumheller, nor the consumptive uses by the many minor allocations. The St. Mary diversions are not and will not be included in the computation of apportionable flow, since this water belongs to the U.S. and is not available to be shared with Saskatchewan. Discussions are currently underway for the inclusion of the minor uses, which are estimated at about 15% of all allocations. However, as urban development is generally considered to generate an increase in runoff which more than offsets the volume consumed through the municipal water distribution systems and as such will not be included in the revisions. Similarly, a large percentage of the minor allocations are located on ephemeral streams, which would have little or no water available for consumption and would not contribute significantly to the apportionable flow during dry years (when apportionment is an issue) will likely not be included in the revised procedures. As such, it is expected that the revisions, when implemented, will have a relatively minor impact (less than 5%) on the apportionable flow and on flows required to be passed to Saskatchewan.

Table 1. Man-made projects included in the computation of apportionable flow.

Category	Sub-Basin	Project	Components
Storage Projects	Oldman	1. Oldman River Dam Reservoir 2. Waterton Reservoir 3. St. Mary Reservoir	a) net evaporation b) change in storage
	Bow	1. Spray Reservoir 2. Lake Minnewanka 3. Ghost Reservoir 4. Upper Kananaskis Reservoir 5. Lower Kananaskis Reservoir 6. Barrier Reservoir 7. Bearspaw Reservoir 8. Glenmore Reservoir	a) net evaporation b) change in storage
	Red Deer	1. Glennifer Reservoir	a) net evaporation b) change in storage
Irrigation Projects	Oldman	1. United Irrigation District 2. Lethbridge Northern I.D. 3. St. Mary Projects (including Magrath, Raymond & Taber) 4. Mountain View I.D. (including Leavitt-Aetna)	a) gross diversions b) return flows
	Bow	1. Western Irrigation District 2. Eastern Irrigation District 3. Bow River Developments (including Highwood Div.)	a) gross diversions b) return flows
Other projects	Red Deer	1. Sheerness 2. Deadfish 3. Buffalo Lake	a) diversion

5 COMPUTATION OF NATURAL FLOWS

Natural flow calculations for the South Saskatchewan River Basin were carried out by Hydrology Branch, Alberta Environment, in their 1998 report entitled "South Saskatchewan River Basin Historical Natural Flows – 1912 to 1995". The study, which was carried out as part of the South Saskatchewan River Basin Planning Program, provides mean weekly natural flows for 78 locations within the basin for the entire 1912 to 1995 period. The study is currently being updated for 1996 to the end of 2001.

The procedure used to derive weekly natural flows was to begin with the daily recorded stream flows and to then add the daily project adjustments so as to create a set of naturalized flows, in which the effects of man-made influences were removed. In general, much of the naturalization, extension, and transfer of data were carried out using computerized procedures in which daily flows were moved through the system using routing models. In instances where the extension or transfer of data could not be accomplished by the use of routing procedures, the extension or transfers were carried out using regression procedures.

The projects that were included in the calculation of natural flows were those whose impact could be quantified from reliable records. In the absence of reliable records, estimates of adjustments were carried out solely for those projects which, if not included, would have had a major impact on the computed natural flows. For the more recent years, the projects included in the computation of natural flows are all of the projects identified in Table 1 as well as the U.S. St. Mary River diversion, the gross diversions and return flows for the cities of Calgary, Red Deer, Drumheller, Lethbridge, and Medicine Hat, and the Gull Lake diversions. A more detailed description of the projects included and the procedures used in the derivation of natural flows may be found in Hydrology Branch's (previously Water Sciences Branch, Alberta Environment) 1998 report "*South Saskatchewan River Basin Historical Natural Flows – 1912 to 1995*". It is noted that the natural flows computed in this report do not take the minor consumptive uses into account, as they could not be readily quantified from reliable records. It is estimated that the natural flows, during dry years when apportionment is an issue, are likely underestimated by 3-5% by the non-inclusion of these minor uses. If these minor uses were taken into account, then the natural flows would increase by a comparable amount. However, as Saskatchewan would be entitled to 50% of the increase, this would mean that the flows passed to Saskatchewan are in fact 1.5-2.5% lower when expressed as a percentage of apportionable flow than what is presented in Table 4, Section 6.2. As such, there is slightly less water available for licensing than may be implied in this report.

6 ASSESSMENT OF SUB-BASIN CONTRIBUTIONS TO APPORTIONMENT

The following sections provide an assessment of the relative contribution of each of the South Saskatchewan River sub-basins to the natural flow and to water-sharing agreements. The assessment of the relative contribution from each of the sub-basins was carried out using the 1975-1995 period data from Alberta Environment. This data set was used because: 1) It is the only data set that has the ability to assess the contributions at a sub-basin level; 2) It provides a more accurate database for the assessment as it is based on finalized data that include U.S. diversions and municipal uses; and 3) The 1975 to 1995 period provides a relatively recent and homogeneous period on which to assess potential trends.

6.1 Sub-Basin Contribution to Natural Flows

Table 2 provides a summary of the annual natural flow for the South Saskatchewan River below the confluence with the Red Deer River and of the relative contributions of each of the sub-basins to the natural flow.

Table 2. Annual natural flow for the South Saskatchewan River below Red Deer River confluence and for major sub-basins.

	South Sask. below Red Deer Confluence	Red Deer near Bindloss	Bow River near The Mouth	Oldman River near The Mouth	Lower South Saskatchewan River
Year	(Dam^3)	(Dam^3)	(Dam^3)	(Dam^3)	(Dam^3)
1975	9,580,752	1,087,607	3,588,372	4,994,939	-90,166
1976	8,639,823	1,074,276	4,075,215	3,447,936	42,397
1977	5,333,035	1,030,928	2,642,535	1,543,505	116,067
1978	9,203,436	1,594,210	4,067,295	3,614,935	-73,005
1979	6,508,266	854,506	2,903,677	2,799,548	-49,464
1980	8,334,138	1,499,104	3,742,998	2,925,498	166,539
1981	11,017,393	2,177,275	4,872,615	3,889,480	78,022
1982	7,917,695	1,803,689	3,384,662	2,766,132	-36,788
1983	6,288,782	1,226,412	3,023,453	2,078,465	-39,549
1984	5,483,209	794,669	2,730,594	1,968,981	-11,036
1985	6,886,759	1,161,005	2,992,281	2,590,804	142,669
1986	9,734,872	2,220,813	4,056,136	3,134,133	323,790
1987	6,763,520	1,153,489	2,967,901	2,520,090	122,039
1988	5,623,752	898,076	3,061,292	1,821,511	-157,126
1989	7,907,157	1,466,145	3,289,479	3,235,650	-84,117
1990	10,983,528	2,663,777	4,630,637	3,765,768	-76,653
1991	10,608,786	1,840,483	4,533,578	4,089,369	145,356
1992	7,339,593	1,536,264	3,615,662	2,151,642	36,025
1993	11,726,461	2,134,214	4,896,620	4,530,314	165,313
1994	7,395,959	1,465,239	3,270,261	2,637,502	22,957
1995	13,111,475	1,962,107	4,618,883	6,506,649	23,836
Average	8,399,447	1,506,871	3,664,959	3,191,088	36,529
Average %		17.9%	43.6%	38.0%	0.4%

As indicated in Table 2, the South Saskatchewan River at the Alberta-Saskatchewan boundary under natural conditions would have had a mean annual flow of about 8,399,447 dam^3 during the 1975 to 1995 period. During this 21-year period, the annual natural flow varied from the 1977 low of 5,333,035 dam^3 (63.5% of average) to the 1995 high of 13,111,475 dam^3 (156.1%of average). The largest sub-basin contribution to the natural flow of the South Saskatchewan River at the Alberta-Saskatchewan boundary is from the Bow River, which on average contributes 3,664,959 dam^3 (43.6% of total), followed by the Oldman River, which contributes 3,191,088 dam^3 (38.0% of total), and the Red Deer River, which contributes 1,506,871 dam^3 (17.9% of total). Table 2 indicates the flow contribution of the Lower South Saskatchewan Basin to be about 36,000 dam^3 or 0.4% of the flow at the interprovincial boundary. However, as the contribution of the Lower South Saskatchewan is not directly measured but rather is estimated as the difference between the flow of the South Saskatchewan at the interprovincial boundary and as measured flows have a measurements error of about +/- 5%, the value, while representative of the relatively minor contribution from this sub-basin, is not considered reliable.

Figure 4 provides the annual percentage contributions of each of the four sub-basins to the natural flow of the South Saskatchewan River at the interprovincial boundary.

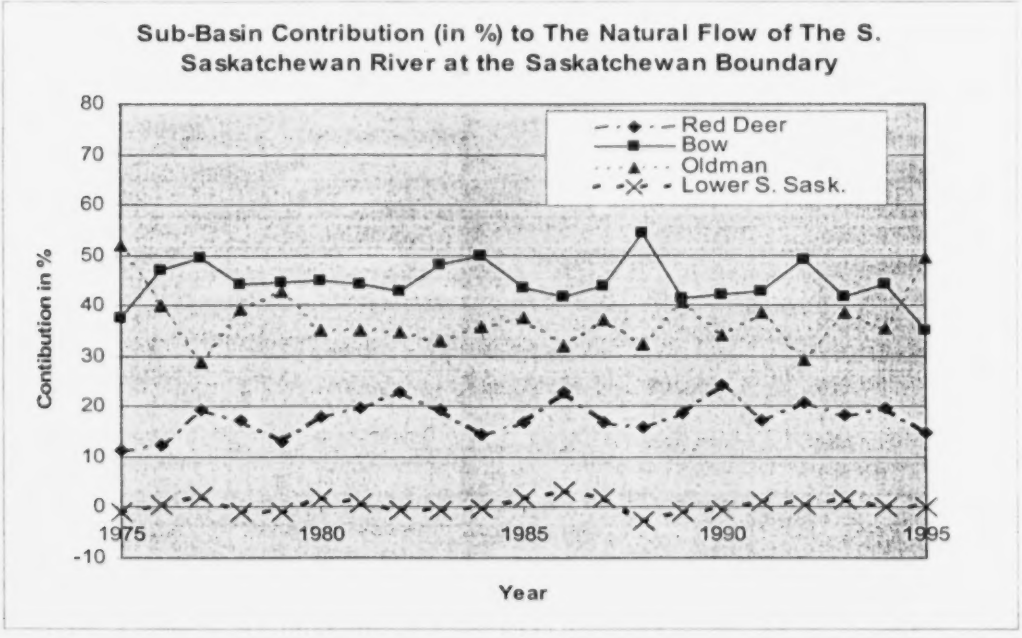

Figure 4. Annual sub-basin contribution (in %) to the South Saskatchewan River natural flow .

As indicated in Figure 4, with the exception of 1975 and 1995, two years in which there were major flood events in the Oldman River basin, the relative contributions from each of the three basins to the natural flow of the South Saskatchewan River did not vary appreciably from year to year.

Table 3 provides a summary of the annual flow in each of the three sub-basins expressed as a percentage of their respective mean annual flow. Within Table 3, blue cells indicate years when the sub-basin flow was 110% or greater of the 21-year average, green cells indicate years when

the sub-basin flow was within +/- 10% of the 21-year average, while red cells indicate years when the sub-basin flow was at 90% or less of the 21-year average.

Table 3. Annual sub-basin flow as a percentage of the sub-basin mean annual flow.

	Red Deer	Bow	Oldman
1975		97.9	156.5
1976		111.2	108.0
1977			
1978	105.8	111.0	113.3
1979			
1980	99.5	102.1	91.7
1981	144.5	133.0	121.9
1982	119.7	92.4	
1983			
1984			
1985			
1986	147.4	110.7	98.2
1987			
1988			
1989	97.3		101.4
1990	176.8	126.3	118.0
1991	122.1	123.7	128.1
1992	102.0	98.7	
1993	141.6	133.6	142.0
1994	97.2		
1995	130.2	126.0	203.9

As indicated in Table 3, during many years (1977, 1979, 1980, 1981, 1983, 1984, 1985, 1987, 1988, 1990, 1991, 1993, and 1995) all three sub-basins exhibited similar conditions in terms of above, below or near average conditions, although of differing magnitudes. However, in about 38% of the years (1975, 1976, 1978, 1982, 1986, 1989, 1992, and 1994), the three basins experience different conditions, in that one or two sub-basins are experienced near average or above average conditions while the others experienced below average conditions.

The 1969 Master Agreement on Apportionment intentionally established the South Saskatchewan River below the confluence with the Red Deer River as the point for apportionment, even though this site is in Saskatchewan. This point was selected as the point for apportionment so as to permit Alberta to meet Saskatchewan's entitlements using any combination of flow from the three sub-basins it desired, thereby providing Alberta with added flexibility in managing its share of the flow of the South Saskatchewan River.

6.2 Annual Deliveries to Saskatchewan versus Apportionment Entitlements

Table 4 provides a summary of the annual apportionable (natural less U.S. diversions) flow, and of Saskatchewan's entitlements and actual deliveries.

the sub-basin flow was within +/- 10% of the 21-year average, while red cells indicate years when the sub-basin flow was at 90% or less of the 21-year average.

Table 3. Annual sub-basin flow as a percentage of the sub-basin mean annual flow.

	Red Deer	Bow	Oldman
1975		97.9	156.5
1976		111.2	108.0
1977			
1978	105.8	111.0	113.3
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1980	99.5	102.1	91.7
1981	144.5	133.0	121.9
1982	119.7	92.4	
1983			
1984			
1985			
1986	147.4	110.7	98.2
1987			
1988			
1989	97.3		101.4
1990	176.8	126.3	118.0
1991	122.1	123.7	128.1
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1993	141.6	133.6	142.0
1994	97.2		
1995	130.2	126.0	203.9

As indicated in Table 3, during many years (1977, 1979, 1980, 1981, 1983, 1984, 1985, 1987, 1988, 1990, 1991, 1993, and 1995) all three sub-basins exhibited similar conditions in terms of above, below or near average conditions, although of differing magnitudes. However, in about 38% of the years (1975, 1976, 1978, 1982, 1986, 1989, 1992, and 1994), the three basins experience different conditions, in that one or two sub-basins are experienced near average or above average conditions while the others experienced below average conditions.

The 1969 Master Agreement on Apportionment intentionally established the South Saskatchewan River below the confluence with the Red Deer River as the point for apportionment, even though this site is in Saskatchewan. This point was selected as the point for apportionment so as to permit Alberta to meet Saskatchewan's entitlements using any combination of flow from the three sub-basins it desired, thereby providing Alberta with added flexibility in managing its share of the flow of the South Saskatchewan River.

6.2 Annual Deliveries to Saskatchewan versus Apportionment Entitlements

Table 4 provides a summary of the annual apportionable (natural less U.S. diversions) flow, and of Saskatchewan's entitlements and actual deliveries.

Table 4. Annual entitlements and deliveries to Saskatchewan.

	Natural Flow at Alberta-Sask. Boundary	U.S Diversions	Apportionable Flow	Saskatchewan Entitlements	Flow delivered to Saskatchewan	% of Apportionable Flow delivered to Saskatchewan
Year	(Dam^3)	(Dam^3)	(Dam^3)	(Dam^3)	(Dam^3)	%
1975	9580752	138267	9442485	4721243	8542441	90.5
1976	8639823	292834	8346989	4173495	6804358	81.5
1977	5333035	147544	5185491	2592746	3288479	63.4
1978	9203436	107947	9095489	4547744	8196892	90.1
1979	6508266	164945	6343321	3171660	4970764	78.4
1980	8334138	264689	8069450	4034725	6126836	75.9
1981	11017393	266511	10750882	5375441	9301008	86.5
1982	7917695	149890	7767805	3883903	5923807	76.3
1983	6288782	213528	6075254	3037627	4065648	66.9
1984	5483209	216576	5266632	2633316	3059737	58.1
1985	6886759	263988	6622770	3311385	4272272	64.5
1986	9734872	175331	9559541	4779771	7586055	79.4
1987	6763520	215498	6548022	3274011	4646224	71.0
1988	5623752	207729	5416023	2708011	3125033	57.7
1989	7907157	347894	7559263	3779631	5019745	66.4
1990	10983528	266235	10717293	5358647	8739840	81.5
1991	10608786	251686	10357100	5178550	8514350	82.2
1992	7339593	172131	7167462	3583731	5032539	70.2
1993	11726461	236309	11490152	5745076	10266783	89.4
1994	7395959	182208	7213751	3606875	5678255	78.7
1995	13111475	123705	12987769	6493885	9995032	77.0
Average	8399447	209783	8189664	4094832	6340767	75.5

As indicated in Table 4 for the 21-year period, Saskatchewan has always received an amount of water that is greater than its entitlement under the 1969 Master Agreement on Apportionment. While Saskatchewan is generally entitled to 50% of the apportionable flow, the actual percentage received has varied from a low of 57.7% in 1988 to more than 90% in 1975.

Figure 5 provides a summary of the percentage of apportionable flow delivered to Saskatchewan versus its entitlements in each of the 21 years assessed. Recently implemented minimum flow requirements for the South Saskatchewan River through Medicine Hat will likely result in increased surplus deliveries to Saskatchewan during dry years.

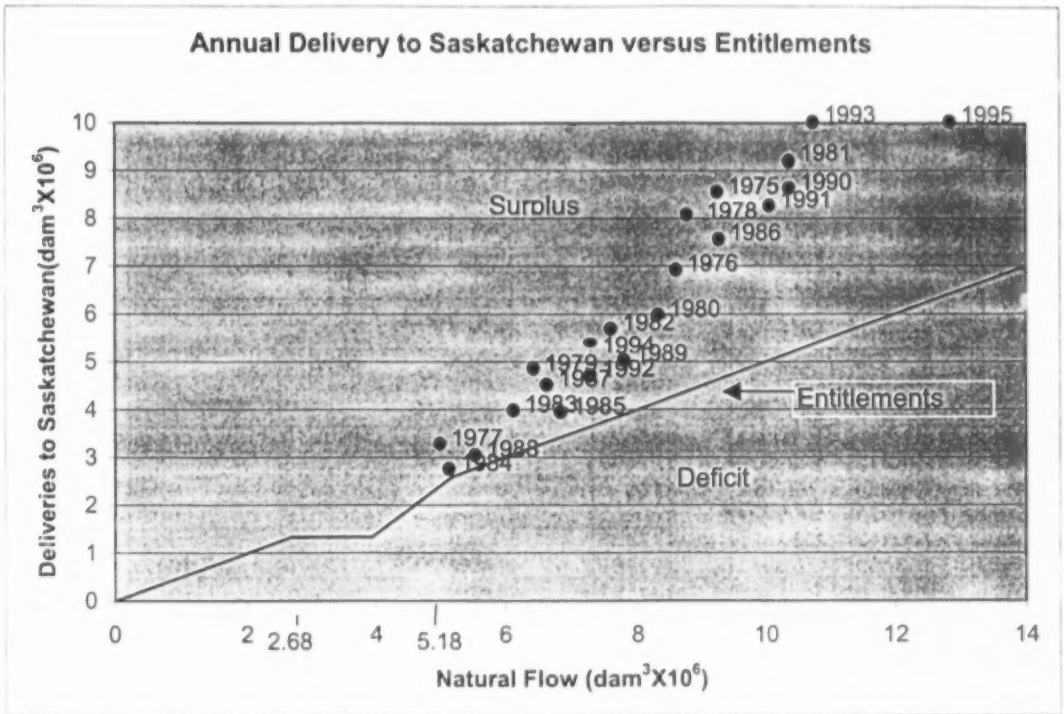

Figure 5. Annual delivery to Saskatchewan versus entitlements.

6.3 Sub-Basin Contributions to Apportionable Flow

The following Sections examine the relative contribution of each of the South Saskatchewan River sub-basins to the total flow delivered to Saskatchewan as well as the contribution to the 1909 Boundary Waters Treaty.

6.3.1 Red Deer River Contribution to Apportionable Flow

The Red Deer River sub-basin is the most northerly of the sub-basins of the South Saskatchewan River. The Red Deer at Bindloss has a drainage area of about 44,700 km^2, about 40.4% of the drainage area of the South Saskatchewan River below the confluence with the Red Deer River. The Red Deer River near Bindloss (immediately upstream of the confluence with the South Saskatchewan River) has a mean annual natural flow of about 1,500,000 dam^3 or about 17.9% of the flow of the South Saskatchewan River. About 88% of the natural flow of the Red Deer River is generated from 25% of the sub-basin drainage area upstream of the City of Red Deer.

Flow modifying projects taken into account in the computation of the natural flow and apportionment contribution of the Red Deer River include items listed in Table 1, as well as the municipal consumptive uses identified in Section 5 and the following return flows:

a) Western Irrigation District Return Flows – Part of the flows diverted from the Bow River by the Western Irrigation District that are returned to the Red Deer River.

b) Eastern Irrigation District Return Flows – Part of the flows diverted by the Eastern Irrigation District that are returned to the Red Deer River.

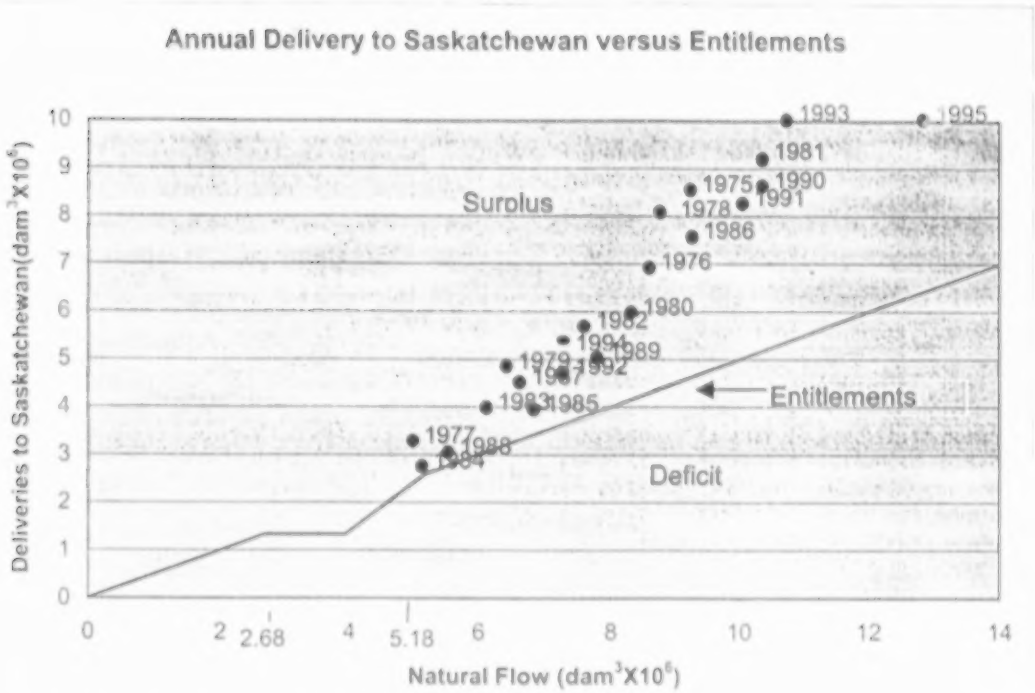

Figure 5. Annual delivery to Saskatchewan versus entitlements.

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The Red Deer River sub-basin is the most northerly of the sub-basins of the South Saskatchewan River. The Red Deer at Bindloss has a drainage area of about 44,700 km^2, about 40.4% of the drainage area of the South Saskatchewan River below the confluence with the Red Deer River. The Red Deer River near Bindloss (immediately upstream of the confluence with the South Saskatchewan River) has a mean annual natural flow of about 1,500,000 dam^3 or about 17.9% of the flow of the South Saskatchewan River. About 88% of the natural flow of the Red Deer River is generated from 25% of the sub-basin drainage area upstream of the City of Red Deer.

Flow modifying projects taken into account in the computation of the natural flow and apportionment contribution of the Red Deer River include items listed in Table 1, as well as the municipal consumptive uses identified in Section 5 and the following return flows:

a) Western Irrigation District Return Flows – Part of the flows diverted from the Bow River by the Western Irrigation District that are returned to the Red Deer River.

b) Eastern Irrigation District Return Flows – Part of the flows diverted by the Eastern Irrigation District that are returned to the Red Deer River.

Table 5 provides a summary of the annual natural flow, the recorded flow, and the flow contributed to apportionment by the Red Deer River. As indicated in Table 5, about 98.4% of the natural flow of the Red Deer River is passed to Saskatchewan.

Table 5. Natural and recorded flow and apportionment contribution for the Red Deer River.

Year	Natural Flow	Recorded Flow	EID Returns to Red Deer R	WID Returns to Red Deer R	Contribution To Apportionment	% of Natural Contributed
	(Dam^3)	(Dam^3)	(Dam^3)	(Dam^3)	(Dam^3)	
1975	1087607	1227029	107088	32251	1087690	100.0
1976	1074276	1246833	135470	39302	1072061	99.8
1977	1030928	1137352	88509	21283	1027560	99.7
1978	1594210	1716658	91647	36415	1588596	99.6
1979	854506	992502	117429	25562	849510	99.4
1980	1499104	1652789	131142	34805	1486842	99.2
1981	2177275	2333890	135927	31531	2166432	99.5
1982	1803689	1970087	135027	33249	1801810	99.9
1983	1226412	1239729	127495	31279	1080956	88.1
1984	794669	927892	116910	36783	774199	97.4
1985	1161005	1309324	120961	37786	1150578	99.1
1986	2220813	2377625	117356	55088	2205181	99.3
1987	1153489	1323941	110169	41600	1172173	101.6
1988	898076	1034239	103191	43790	887257	98.8
1989	1466145	1543728	91153	33822	1418753	96.8
1990	2663777	2793946	101544	35620	2656782	99.7
1991	1840483	1954545	120889	33842	1799815	97.8
1992	1536264	1628156	114827	42883	1470446	95.7
1993	2134214	2219803	82693	36461	2100649	98.4
1994	1465239	1572184	86429	31614	1454141	99.2
1995	1962107	2034305	106460	31332	1896513	96.7
Average	1506871	1630312	111539	35538	1483235	98.4

Figure 6 provides a comparison of the natural and recorded flow contributed to apportionment by the Red Deer River in a typical recent year.

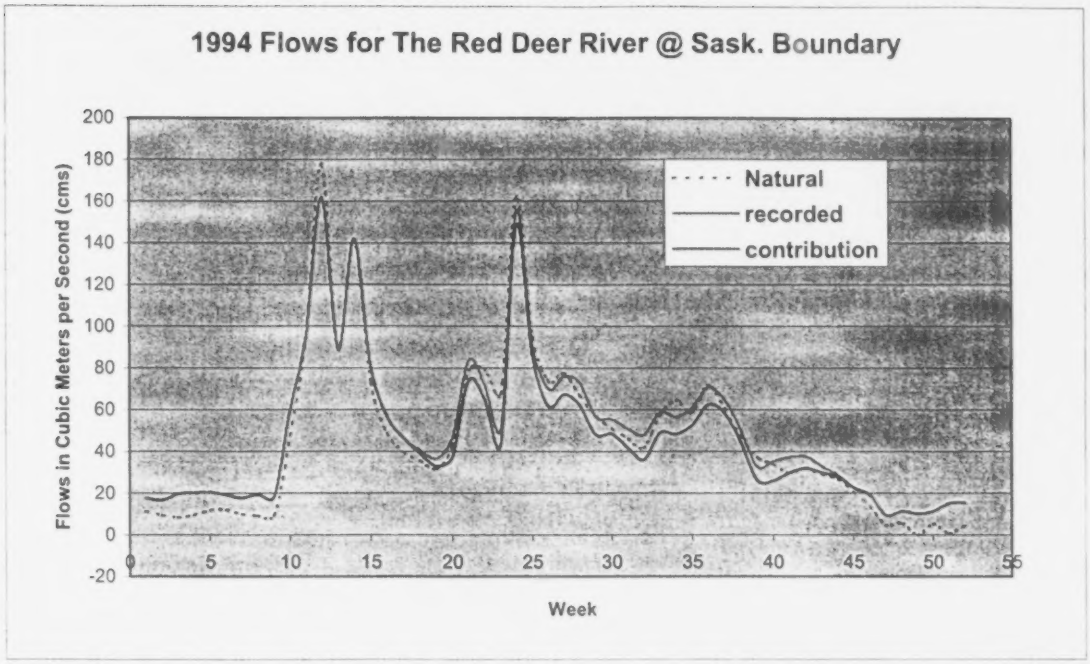

Figure 6. Natural & recorded flow and apportionment contribution for the Red Deer River in 1994.

As indicated in Figure 6, the natural flows of the Red Deer River are modified by the operation of the Dickson Dam, which captures some flow volume throughout the summer and releases water during the winter months resulting in winter flows that are well above natural. In general, during the summer months, the reduction in flows due to storage by Dickson Dam and consumptive diversions by other projects is offset by return flows from the EID and WID.

Figure 7 provides a summary of the percentage of natural flow within the Red Deer River that was delivered annually to Saskatchewan and that contributes to the apportionment deliveries. Since Alberta has had significant surplus apportionment deliveries in all years, the large percentage of the natural flow of the Red Deer River delivered to Saskatchewan appears to be due to the non consumption and lack of major storage devices in the basin rather than due to policy requirements.

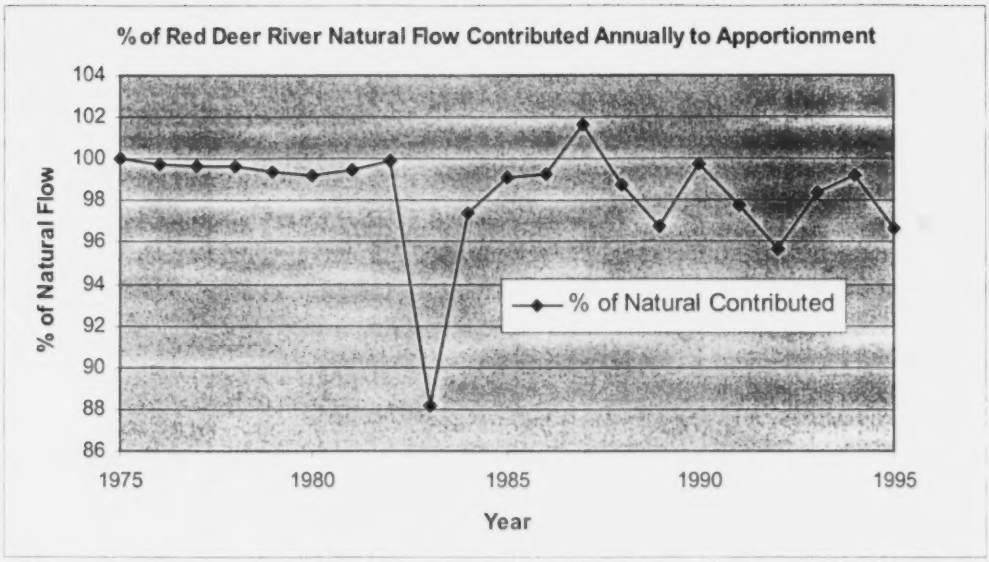

Figure 7. Percentage of natural flow of the Red Deer River contributed annually to apportionment.

As indicated in Figure 7, prior to 1983 nearly all of the natural flows of the Red Deer River were delivered to Saskatchewan. The filling of Glennifer Reservoir in 1983 reduced that year's contribution to about 88% of natural, while the release of flow captured in previous years resulted in deliveries of about 102% of natural in 1987, when dry conditions required late fall releases that exceeded storage in that year. While the contribution to apportionment has declined in recent years, this decline is a modest 1-2% with overall contributions remaining at about 98% of natural.

6.3.2 Bow River Contribution to Apportionable Flow

The Bow River at its confluence with the Oldman River has a drainage area of about 25,300 km^2 or about 22.9% of the drainage area of the South Saskatchewan River Basin. The Bow River at the Mouth has a mean annual natural flow of 3,660,000 dam^3 or about 43.6% of the total natural flow of the South Saskatchewan River at the point of apportionment.

Flow modifying projects taken into account in the computation of the natural flow and apportionment contribution of the Bow River include all items listed in Table 1, as well as municipal consumptive uses identified in Section 5. The following return flows were also taken into account in the derivation of flows contributed to apportionment:

a) Western Irrigation District Return Flows to The Red Deer River – Part of the flows diverted from the Bow River by the WID that are returned to the Red Deer River.

b) Eastern Irrigation District Return Flows to the Red Deer River – Part of the flows diverted from the Bow by the EID that are returned to the Red Deer River.

c) Bow River Irrigation District Return Flows to the South Saskatchewan River below the Bow River confluence – Part of the flows diverted from the Bow by the BRID that are returned to the South Saskatchewan River immediately below the Bow River and Oldman River confluence.

d) Bow River Irrigation District Return Flows to the Oldman River above the Mouth – Part of the flows diverted from the Bow by the BRID that are returned to the Oldman River above the confluence.

Table 6 provides a summary of the annual natural flow, the recorded flow, and the flow contributed to apportionment by the Bow River.

Table 6. Natural and recorded flow and apportionment contribution for the Bow River.

Year	Natural Flow	Recorded Flow	EID Returns to Red Deer R	WID Returns to Red Deer R	BRID Returns to the S.Sask	BRID Returns to the Oldman	Contribution To Apportionment	% of Natural Contributed
	(Dam^3)		(Dam^3)	(Dam^3)	(Dam^3)	(Dam^3)	(Dam^3)	
1975	3588372	2912424	107088	32251	26071	15797	3093631	86.2
1976	4075215	2887202	135470	39302	23531	23808	3109313	76.3
1977	2642535	1387026	88509	21283	23869	23119	1543805	58.4
1978	4067295	3280855	91647	36415	21577	16360	3446854	84.7
1979	2903677	1950123	117429	25562	19009	18561	2130684	73.4
1980	3742998	2514571	131142	34805	20774	21185	2722476	72.7
1981	4872615	3834088	135927	31531	25727	21609	4048882	83.1
1982	3384662	2293274	135027	33249	30541	19729	2511821	74.2
1983	3023453	1828741	127495	31279	23777	25560	2036851	67.4
1984	2730594	1385737	116910	36783	13436	18353	1571219	57.5
1985	2992281	1604068	120961	37786	13047	19310	1795172	60.0
1986	4056136	2746737	117356	55088	14150	23129	2956461	72.9
1987	2967901	1840870	110169	41600	14594	22591	2029824	68.4
1988	3061292	1563306	103191	43790	19792	28733	1758812	57.5
1989	3289479	1967949	91153	33822	18114	21315	2132353	64.8
1990	4630637	3371488	101544	35620	22665	21674	3552991	76.7
1991	4533578	3390157	120889	33842	22671	19910	3587467	79.1
1992	3615662	2383162	114827	42883	25329	23922	2590124	71.6
1993	4896620	4062500	82693	36461	21383	18720	4221757	86.2
1994	3270261	2175543	86429	31614	29659	21144	2344389	71.7
1995	4618883	3487356	106460	31332	23988	18259	3667395	79.4
Average	3664959	2517485	111539	35538	21605	21085	2707251	72.5

As indicated in Table 6, the Bow River has a mean annual natural flow of about 3,660,000 dam^3. This has varied from a low of about 2,640,000 dam^3 in 1977 to a high of about 4,600,000 dam^3 in 1990 and 1995. The relative proportion of the natural flow of the Bow River delivered to Saskatchewan, while averaging about 72.5%, but has varied from a low of about 57.5% in 1984 and 1988 to a high of about 86.2% in 1975 and 1993.

Figure 8 provides a comparison of the natural and recorded flow and the Bow River contribution to apportionment in a typical recent year.

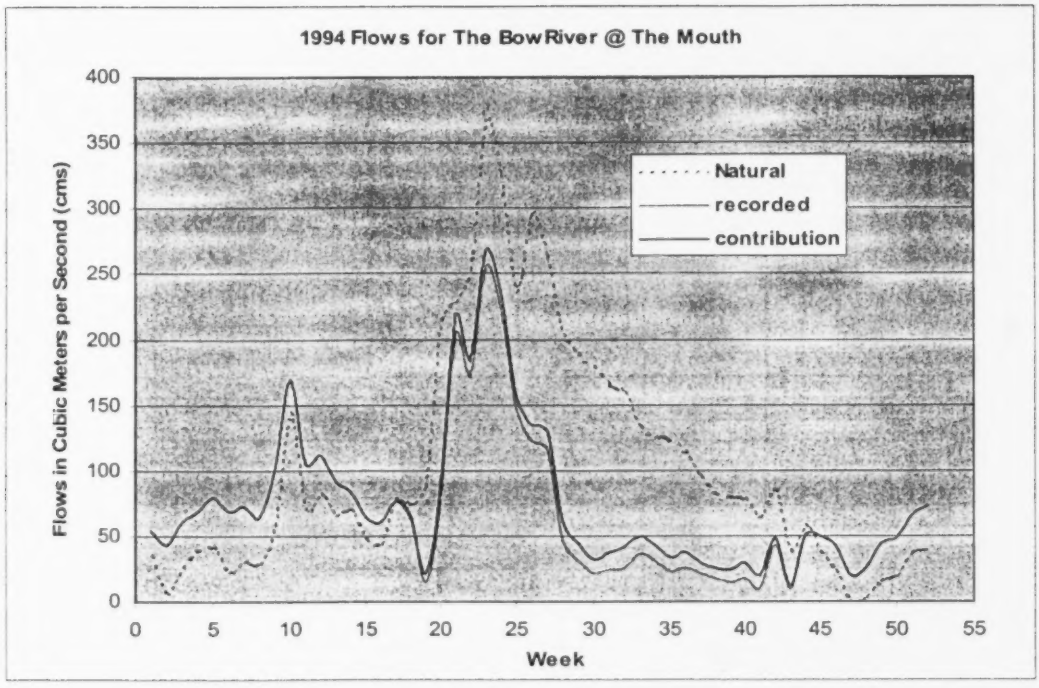

Figure 8. Natural and recorded flow and apportionment contribution for the Bow River in 1994.

As indicated in Figure 8, the recorded and apportionment flows in the Bow River are significantly reduced from their natural levels during the summer months as a result of irrigation diversions and storage in the power reservoirs. The flows are above their natural levels in the late fall, winter and early spring as a result of releases from storage for power production.

Figure 9 provides a summary of the percentage of natural flow within the Bow River that has been delivered annually to Saskatchewan and that contributes to the South Saskatchewan apportionment deliveries.

As indicated in Figure 9, there does not appear to be any systemic trend in the general percentage of the Bow River natural flow contributed to apportionment with time. While Figure 9 indicates a drop in the mid to late 1980s, this temporary drop is attributed to low natural flow conditions that persisted throughout much of this period rather than to changes in management practices.

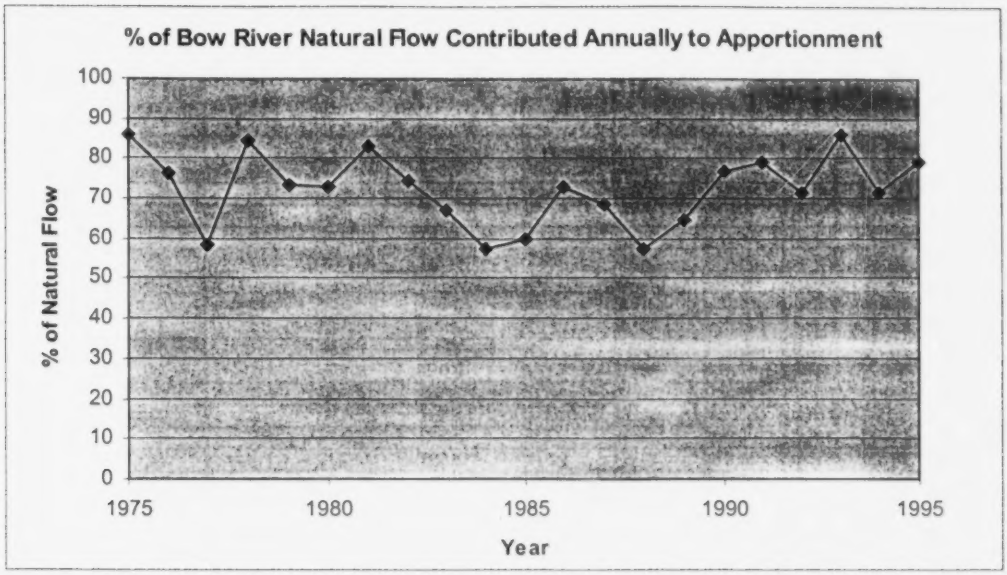

Figure 9. Percentage of the natural flow of the Bow River contributed annually to apportionment.

6.3.3 Oldman River Contribution to Apportionable Flow

The Oldman River sub-basin at its confluence with the Bow River has a drainage area of about 27,500 km^2 or about 24.8% of the drainage area of the South Saskatchewan River Basin. The Oldman River at the Mouth has a mean annual natural flow of about 3,191,000 dam^3 or about 38% of the total flow of the South Saskatchewan at the point of apportionment.

Flow modifying projects taken into account in the computation of the natural flow and apportionment contribution of the Oldman River include all items listed in Table 1, as well as United States diversions and municipal consumptive uses identified in Section 5. The following return flows were also taken into account in the derivation of flows contributed to apportionment:

a) St Mary River Irrigation District Return Flows to the South Saskatchewan River below Medicine Hat – Part of the flows diverted from the St. Mary, and Waterton Rivers by the SMRID that are returned to the South Saskatchewan near Medicine Hat.

b) St Mary River Irrigation District Return Flows to the South Saskatchewan River above Medicine Hat – Part of the flows diverted from the St. Mary, and Waterton Rivers by the SMRID that are returned to the reach of the South Saskatchewan between the Bow River, Oldman River confluence and Medicine Hat.

c) Bow River Irrigation District Return Flows to the Oldman River above the Mouth – Part of the flows diverted from the Bow by the BRID that are returned to the Oldman River above the confluence.

Table 7 provides a summary of the annual natural flow, the recorded flow, and the flow contributed to apportionment by the Oldman River.

Table 7. Natural and recorded flow and apportionment contributions for the Oldman River.

Year	Natural Flow	U.S. Diversions	Apportionable Flow	Recorded Flow	BRID Return to Oldman R	SMRID Returns below Med Hat	SMRID Returns above Med Hat	Contribution To Interprovincial Apportionment	% of Natural Diverted by U.S.	% of Apportionable passed to Sask.	Total % of Natural to U.S. & Sask.
	(Dam^3)	(Dam^3)	(Dam^3)	(Dam^3)	(Dam^3)	(Dam^3)	(Dam^3)	(Dam^3)	%	%	%
1975	4994939	138267	4856672	4454136	15797	10916	10118	4459974	2.8	91.8	92.0
1976	3447906	292834	3155102	2590705	23808	16430	15227	2598554	8.5	82.4	83.9
1977	1543505	147544	1395962	645598	23119	17171	15915	655566	9.6	47.0	52.0
1978	3614935	107947	3506988	3098436	16360	14220	13180	3109476	3.0	88.7	89.0
1979	2799548	164945	2634602	2047914	18561	15382	14256	2058992	5.9	78.2	79.4
1980	2925498	264689	2660809	1891781	21185	17046	15798	1903441	9.0	71.5	74.1
1981	3889480	266511	3622970	2973728	21609	24656	22850	2999625	6.9	82.8	84.0
1982	2766132	149890	2616242	1832825	19729	27179	25191	1865465	5.4	71.3	72.9
1983	2078465	213528	1864937	1073954	25560	31398	29104	1106896	10.3	59.5	63.6
1984	1968981	216576	1752405	743576	18353	29302	27159	781686	11.0	44.6	50.7
1985	2590804	263988	2326815	1228658	19310	22773	21105	1253227	10.2	53.9	58.6
1986	3134133	175331	2958802	2138596	23129	35598	32993	2184058	5.6	73.8	75.3
1987	2520090	215498	2304592	1404568	22591	26832	24865	1433674	8.6	62.2	65.4
1988	1821511	207729	1613782	651783	28733	22124	20605	665679	11.4	41.2	47.9
1989	3235650	347894	2887756	1591331	21315	20400	18906	1609323	10.8	55.7	60.5
1990	3765768	266235	3499533	2591761	21674	22106	20487	2612679	7.1	74.7	76.4
1991	4089069	251686	3837683	2983911	19910	26560	24617	3015179	6.2	78.6	79.9
1992	2151642	172131	1979511	921084	23922	25832	23942	946935	8.0	47.8	52.0
1993	4530314	236309	4294005	3881259	18720	32721	30327	3925567	5.2	91.4	91.9
1994	2637502	182208	2455294	1868625	21144	23703	21969	1893153	6.9	77.1	78.7
1995	6506649	123705	6382944	4404890	18259	24450	22661	4433745	1.9	69.5	70.0
Average	3191088	209783	2981305	2143768	21085	23181	21485	2167348	7.3	68.7	71.3

As indicated in Table 7, the Oldman River has a mean annual natural flow of about 3,190,000 dam^3. This has varied from a low of about 1,543,000 dam^3 in 1977 to a high of about 6,506,000 dam^3 in 1995. The waters of the Oldman River are subject to two water-sharing agreements, the 1909 Boundary Waters Treaty and the 1969 Master Agreement on Apportionment. Under the Boundary Waters Treaty the United States has diverted a mean annual volume of about 210,000 dam^3 from the St. Mary River, about 7.3% of the natural flow of the Oldman River near the Mouth. The actual quantity diverted has varied from a low of about 108,000 in 1978 to a high of about 347,000 in 1989. On a percentage basis, the annual U.S. diversions have varied from a low of about 1.9% of the natural flow of the Oldman River during the extremely wet 1995 to a high of about 11.4% in the dry 1988. In general, the U.S diversions are a greater percentage of total (about 10%) during dry years. This is due to the size of their storage and diversion infrastructure, which is inadequate to store and divert the full U.S. entitlement during wet years. The quantity and relative percentage diverted by the U.S. will increase if the U.S. implements proposed structural modifications. Under the 1969 Master Agreement on Apportionment, Saskatchewan is entitled to about 50% (see Section 5 for detailed discussion) of the apportionable flow (natural flow less U.S. diversions) of the South Saskatchewan River below the confluence with the Red Deer River.

While this section examines the relative contribution of the Oldman River to Apportionment, the Agreement does not limit Alberta as to the quantity that may be delivered from each of the sub-basins. As indicated in Table 6, the relative proportion of the "apportionable" flow of the Oldman River delivered to Saskatchewan, while averaging about 68.7%, has varied from a low of about 41.2% in 1988 to a high of more than 91% in 1975 and 1993. The Oldman basin has contributed less than 50% of its apportionable flow towards meeting Saskatchewan's entitlements in 4 of the 21 years (1977, 1984, 1988, and 1992). In general, the years when the Oldman basin has contributed less than 50% of its apportionable flow are relatively dry years having an annual

runoff of less than 2,150,000 dam^3 or less than 69% of average. While the Oldman basin has contributed less than 50% of its apportionable towards deliveries to Saskatchewan in 4 of 21 years:

a) The total flow contributed towards all water-sharing agreements has been greater than 50% in all years except 1988, a year in which natural flow was a mere 57%of natural. Even under the extremely dry conditions in 1988, the U.S. diverted 11.4% of natural, while 41.2% of apportionable (36.5% of natural) was delivered to Saskatchewan for a combined total delivery to both water-sharing agreements of 47.9% of natural.

b) In recognition of existing irrigation requirements at the time that the Master Agreement on Apportionment was signed, Alberta was granted a volume greater than 50% of apportionable for years in which the apportionable flow of the South Saskatchewan below the Red Deer confluence is less than 5,180,000 dam^3.

c) Even during these extremely dry years, Alberta had surplus deliveries of between 400,000 and 1,500,000 dam^3 (Table 3).

Figure 10 provides a comparison of the natural and recorded flow and the Oldman River contribution to apportionment in a typical recent year.

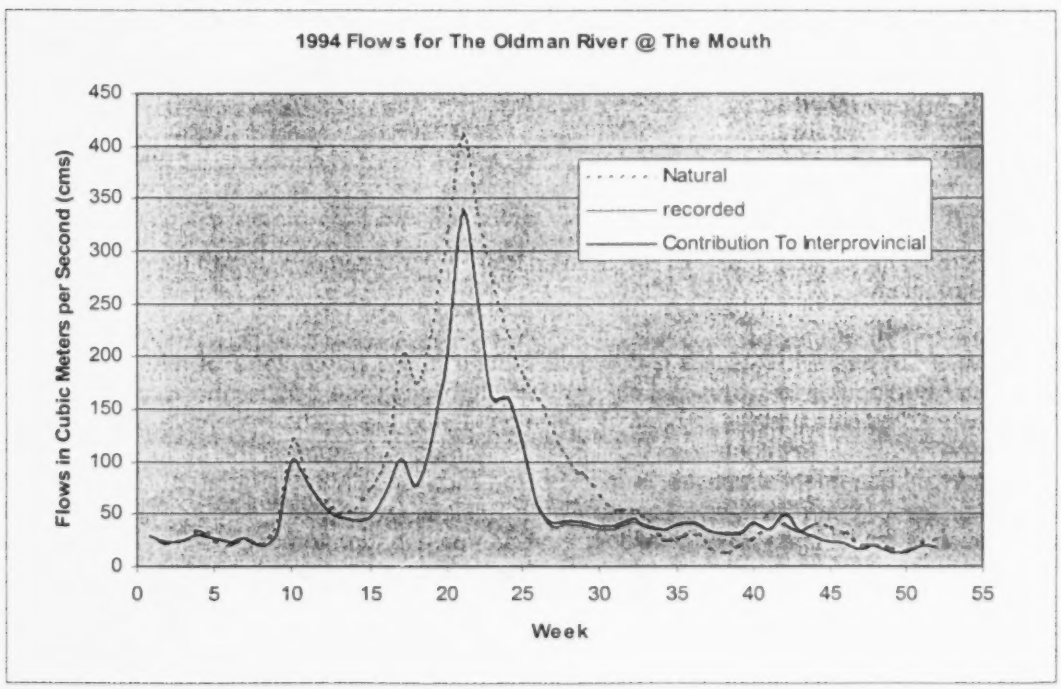

Figure 10. Natural & recorded flow and apportionment contribution for the Oldman River in 1994.

As indicated in Figure 10, the recorded and apportionment flows in the Oldman River are significantly reduced from their natural levels during the spring and summer months as a result of U.S. diversions, irrigation diversions and reservoir storage. While not clearly shown in Figure

10, as 1994 was the first year of operation of the Oldman Dam, flows are above natural levels in the late fall, winter and early spring as a result of flow releases from the Oldman Dam.

Figure 11 provides a summary of the percent of natural flow within the Oldman basin that has been contributed annually to the water-sharing Agreements with the U.S. and Saskatchewan.

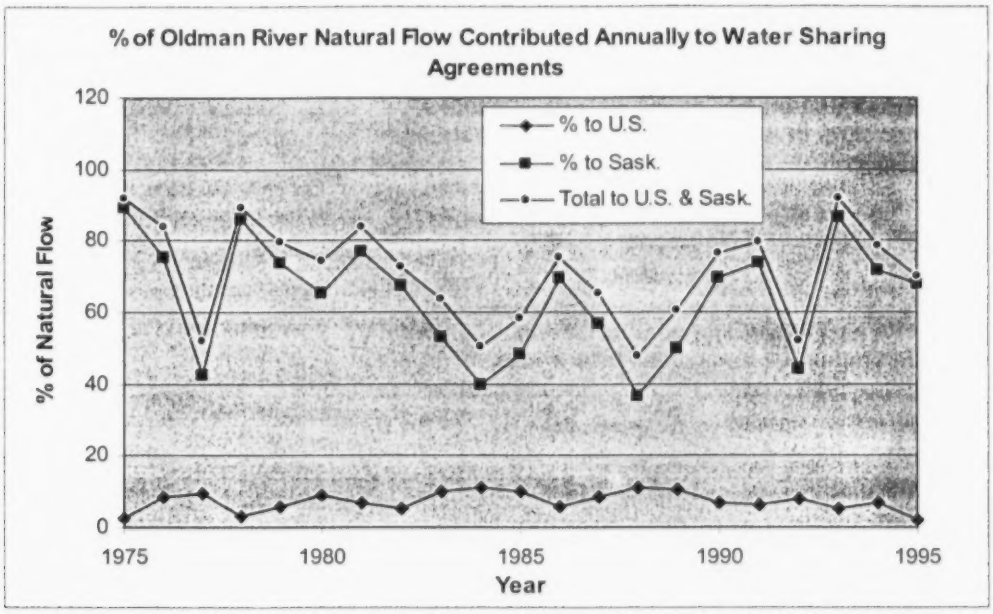

Figure 11. Percentage of natural flow of the Oldman River contributed annually to water-sharing agreements.

While Figure 11 appears to indicate a downward trend in the percentage of natural flow the Oldman River contributes to water-sharing agreements during the 1980s, the recovery in the mid 1990s would indicate that the decline in deliveries during the 1980s may have been more a function of the extremely dry conditions that persisted throughout much of the period rather than to changes in management practices. It is expected that recently implemented instream flow objectives for the Oldman River and for the South Saskatchewan River through Medicine Hat will likely result in the Oldman River providing a greater contribution to apportionment during low flow years.

6.3.4 Lower South Saskatchewan Contribution to Apportionable Flow

The Lower South Saskatchewan River sub-basin is comprised of those areas between the confluence of the Bow and Oldman River and the confluence of the Red Deer River with the South Saskatchewan. It has a drainage area of about 13,200 km^2 or about 11.9% of the drainage area of the South Saskatchewan River Basin. The area in general has relatively low runoff with most of the contributing tributaries in the area often flowing solely for a very brief period during the early spring. As there are no direct means of quantifying the runoff

contribution from this area, the annual natural flow was computed by subtracting the estimated natural flow of the three upstream sub-basins from the estimated natural flow of the South Saskatchewan River at the confluence with the Red Deer River (Table 2). As indicated in Table 2 the annual natural flow contribution from this area is estimated at about 36,500 dam^3 or about 0.4% of the natural flow of the South Saskatchewan River. However, while the estimate is indicative of the relatively low contributions of this area to the overall flow of the South Saskatchewan River, the absolute value is not considered reliable since:

a) The estimated contribution for the Lower South Saskatchewan is appreciably smaller than the measurement error of +/-5%: and

b) This reach of the South Saskatchewan River frequently experiences evaporation and seepage losses, associated with the conveyance of upstream flows, that are often greater than the local runoff contribution.

In view of the relatively minor contribution from this area and the inaccuracies of the estimated contribution, this area is not considered in the overall assessment of sub-basin contributions.

6.4 Annual Sub-Basin Contributions to Water-Sharing Agreements

Table 8 provides a summary of the annual diversions by the U.S. and of the annual delivery of water from each of the three sub-basins to Saskatchewan.

Table 8. Annual water diversions by the U.S. and sub-basin deliveries to Saskatchewan.

	Natural Flow at AB-Sask. Boundary	U.S Diversions	Apportionable Flow	Saskatchewan Entitlements	Red Deer River Deliveries to Sask.	Bow River Deliveries to Sask.	Oldman River Deliveries to Sask.	U.S Diversions from Oldman River	Flow delivered to Sask.	Total Deliveries to Water Share Agreements
Year	(Dam^3)	(Dam^3)	(Dam^3)	(Dam^3)	(Dam^3)	(Dam^3)	(Dam3)	(Dam^3)	(Dam^3)	(Dam^3)
1975	9,580,752	138,267	9,442,485	4,721,243	1,087,690	3,093,631	4,459,374	138,267	8,542,441	8,680,708
1976	8,639,823	292,834	8,346,989	4,173,495	1,072,061	3,109,313	2,598,554	292,834	6,804,358	7,097,193
1977	5,333,035	147,544	5,185,491	2,592,746	1,027,560	1,543,805	655,566	147,544	3,288,479	3,436,023
1978	9,203,436	107,947	9,095,489	4,547,744	1,588,596	3,446,854	3,109,476	107,947	8,196,892	8,304,839
1979	6,508,266	164,945	6,343,321	3,171,660	849,510	2,130,684	2,058,992	164,945	4,970,764	5,135,710
1980	8,334,138	264,689	8,069,450	4,034,725	1,486,842	2,722,476	1,903,441	264,689	6,126,836	6,391,524
1981	11,017,393	266,511	10,750,882	5,375,441	2,166,432	4,048,882	2,999,625	266,511	9,301,008	9,567,518
1982	7,917,695	149,890	7,767,805	3,883,903	1,801,810	2,511,821	1,865,465	149,890	5,923,807	6,073,697
1983	6,288,782	213,528	6,075,254	3,037,627	1,080,956	2,036,851	1,108,896	213,528	4,065,648	4,279,176
1984	5,483,209	216,576	5,266,632	2,633,316	774,199	1,571,219	781,686	216,576	3,059,737	3,276,314
1985	6,886,759	263,988	6,622,770	3,311,385	1,150,578	1,795,172	1,253,227	263,988	4,272,272	4,536,260
1986	9,734,872	175,331	9,559,541	4,779,771	2,205,181	2,956,461	2,184,058	175,331	7,586,055	7,761,386
1987	6,763,520	215,498	6,548,022	3,274,011	1,172,173	2,029,824	1,433,674	215,498	4,646,224	4,861,723
1988	5,623,752	207,729	5,416,023	2,708,011	887,257	1,758,812	665,679	207,729	3,125,033	3,332,762
1989	7,907,157	347,894	7,559,263	3,779,631	1,418,753	2,132,353	1,609,323	347,894	5,019,745	5,367,639
1990	10,983,528	266,235	10,717,293	5,358,647	2,656,782	3,552,991	2,612,679	266,235	8,739,840	9,006,075
1991	10,608,786	251,686	10,357,100	5,178,550	1,799,815	3,587,467	3,015,179	251,686	8,514,350	8,766,036
1992	7,339,593	172,131	7,167,462	3,583,731	1,470,446	2,590,124	946,935	172,131	5,032,539	5,204,670
1993	11,726,461	236,309	11,490,152	5,745,076	2,100,649	4,221,757	3,925,587	236,309	10,266,783	10,503,093
1994	7,395,959	182,208	7,213,751	3,606,875	1,454,141	2,344,389	1,893,153	182,208	5,678,255	5,860,463
1995	13,111,475	123,705	12,987,769	6,493,885	1,896,513	3,667,395	4,433,745	123,705	9,995,032	10,118,738
Average	8,399,447	209,783	8,189,664	4,094,832	1,483,235	2,707,251	2,167,348	209,783	6,340,767	6,550,550

As indicated in Table 8, the mean annual delivery to Saskatchewan is about 6,340,000 dam^3, or 75.5% of natural. The surplus delivery to Saskatchewan has averaged about 2,240,000 dam^3 per year more than its entitlements, although the surplus has varied from a low of about 417,000 dam^3 in the very dry 1988 to a high of 4,522,000 dam^3 in the relatively wet 1993.

The annual sub-basin contribution has averaged, 1,483,000 dam^3 for the Red Deer River, 2,707,000 dam^3 for the Bow River, and 2,167,000 dam^3 for the Oldman River. In addition to the 2,167,000 dam^3 the Oldman River has delivered to Saskatchewan, the basin also contributed

about 210,000 dam^3 annually towards the 1909 Boundary Waters Treaty for a total contribution of 2,377,000 towards water-sharing agreements.

Table 9 provides a summary of the percentage of total annual deliveries towards water-sharing agreements from each sub-basin. The percentage of annual contributions to all water-sharing agreements from each sub-basin are shown in Figure 12.

Table 9. Percentage of total annual deliveries towards water-sharing agreements.

	Natural Flow at AB-Sask. Boundary	U.S Diversions	Apportionable Flow	Flow delivered to Sask.	Total Deliveries to Water Share Agreements	Red Deer River Deliveries as a % of		Bow Deliveries as a % of		Oldman Deliveries as a % of	
						Delivery to Sask.	Delivery to all water Share Agreements	Delivery to Sask.	Delivery to all water Share Agreements	Delivery to Sask.	Delivery to all water Share Agreements
Year	(Dam^3)	(Dam^3)	(Dam^3)	(Dam^3)	(Dam^3)	%	%	%	%	%	%
1975	9,580,752	138,267	9,442,485	8,542,441	8,680,708	12.7	12.5	36.2	35.6	52.2	53.0
1976	8,639,823	292,834	8,346,989	6,804,358	7,097,193	15.8	15.1	45.7	43.8	38.2	40.7
1977	5,333,035	147,544	5,185,491	3,288,479	3,436,023	31.2	29.9	46.9	44.9	19.9	23.4
1978	9,203,436	107,947	9,095,489	8,196,892	8,304,839	19.4	19.1	42.1	41.5	37.9	38.7
1979	6,508,266	164,945	6,343,321	4,970,764	5,135,710	17.1	16.5	42.9	41.5	41.4	43.3
1980	8,334,138	264,689	8,069,450	6,126,836	6,391,524	24.3	23.3	44.4	42.6	31.1	33.9
1981	11,017,393	266,511	10,750,882	9,301,008	9,567,518	23.3	22.6	43.5	42.3	32.3	34.1
1982	7,917,695	149,890	7,767,805	5,923,807	6,073,697	30.4	29.7	42.4	41.4	31.5	33.2
1983	6,288,782	213,528	6,075,254	4,065,648	4,279,176	26.6	25.3	50.1	47.6	27.3	30.9
1984	5,483,209	216,576	5,266,632	3,059,737	3,276,314	25.3	23.6	51.4	48.0	25.5	30.5
1985	6,886,759	263,988	6,622,770	4,272,272	4,536,260	26.9	25.4	42.0	39.6	29.3	33.4
1986	9,734,872	175,331	9,559,541	7,586,055	7,761,386	29.1	28.4	39.0	38.1	28.8	30.4
1987	6,763,520	215,498	6,548,022	4,646,224	4,861,723	25.2	24.1	43.7	41.8	30.9	33.9
1988	5,623,752	207,729	5,416,023	3,125,033	3,332,762	28.4	26.6	56.3	52.8	21.3	26.2
1989	7,907,157	347,894	7,559,263	5,019,745	5,367,639	28.3	26.4	42.5	39.7	32.1	36.5
1990	10,963,528	266,235	10,717,293	8,739,840	9,006,075	30.4	29.5	40.7	39.5	29.9	32.0
1991	10,608,786	251,686	10,357,100	8,514,350	8,766,036	21.1	20.5	42.1	40.9	35.4	37.3
1992	7,339,593	172,131	7,167,462	5,032,539	5,204,670	29.2	28.3	51.5	49.8	18.8	21.5
1993	11,726,461	236,309	11,490,152	10,266,783	10,503,093	20.5	20.0	41.1	40.2	38.2	39.6
1994	7,395,959	182,208	7,213,751	5,678,255	5,860,463	25.6	24.8	41.3	40.0	33.3	35.4
1995	13,111,475	123,705	12,987,769	9,995,032	10,118,738	19.0	18.7	36.7	36.2	44.4	45.0
Average	8,399,447	209,783	8,189,664	6,340,767	6,550,550	24.3	23.4	43.9	42.3	32.4	34.9

(Note: total percentages may vary slightly from 100% due to non-inclusion of the Lower South Saskatchewan Basin)

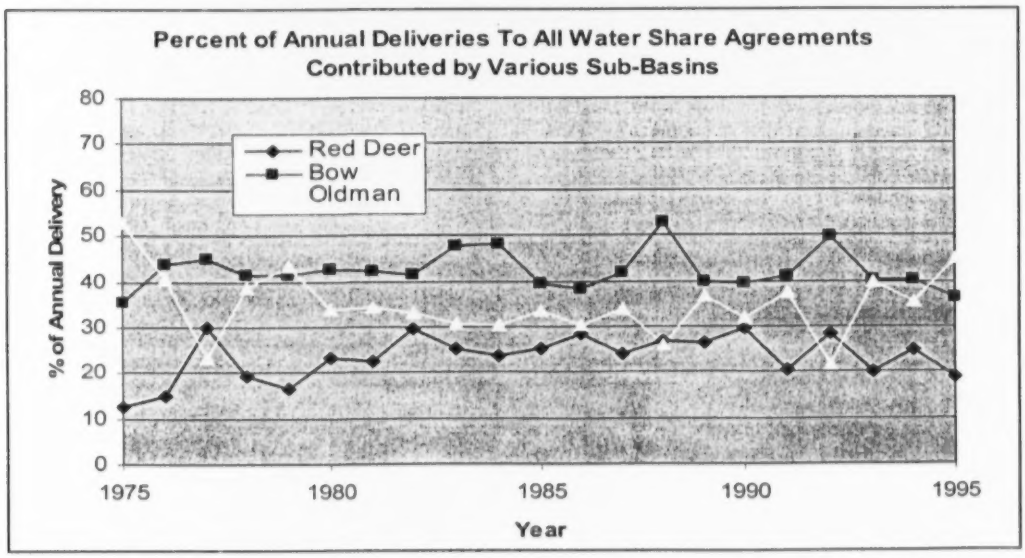

Figure 12. Percentage of total annual deliveries from each sub-basin to all water-sharing agreements.

As indicated in Table 9 and Figure 12, the mean annual delivery to Saskatchewan (apportionment) from each of the Red Deer, Bow and Oldman sub-basins is 24.3%, 43,9% and 32.4%, respectively. The mean annual contribution to deliveries under all water-sharing agreements from each of the Red Deer, Bow and Oldman sub-basins is 23.4% 42.3% and 34.9 %, respectively. In 1992, the contribution from the Oldman River to water-sharing agreements appears to have fallen significantly below its long-term average relative to the other sub-basins and in fact to less than the contribution from the Red Deer River which generally has a considerably lower natural flow. While the relative delivery to all water-sharing agreements from the Oldman sub-basin in 1992 was only 21.5%, this was a year in which the Oldman basin experienced significantly below average flows while both the Red Deer and Bow sub-basins had near average flows. The flow delivered from the Oldman sub-basin to the various water-sharing agreements in 1992 represented 52% of the Oldman natural flow for that year.

7 RED DEER CONTRIBUTIONS REQUIRED TO MEET APPORTIONMENT

Concerns have been raised that development within the Red Deer basin may have been compromised by the need for the Red Deer River basin to contribute a volume greater than 50% of its natural flow to apportionment to offset consumption in the Bow and Oldman River basins. This section addresses this concern by examining the flow contribution required from the Red Deer River, during the 1975 to 1995 period, to ensure that apportionment was met.

Table 10 provides a summary of the apportionment requirements and of the contribution to apportionment from each of the four sub-basins. Column 8, Table 10, shows the flow volume required from the Red Deer basin to meet apportionment, column 10 expresses this volume as a percent of the Red Deer River natural flow. The values in column 8 were derived by subtracting the Bow contribution (column 5), the Oldman contribution (column 6), and the Lower South Saskatchewan contribution (column 7) from Saskatchewan entitlements (column 3).

Table 10. Flow contribution required from the Red Deer River to meet apportionment.

	Apportionable Flow	Sask. Entitlement	Red Deer R. Contribution	Bow River Contribution	Oldman R. Contribution	Lower S.Sask. Contrib.	Vol. Req. from Red Deer	Red Deer Nat. Flow	Vol. Req.as % of Red Deer nat.
Year	(Dam^3)	(Dam^3)	(Dam^3)	(Dam^3)	(Dam^3)	(Dam^3)	(Dam^3)	(Dam^3)	%
1975	9,445,994	4,722,997	1,087,690	3,093,631	4,459,374	-98,253	0	1,087,607	0.0
1976	8,345,051	4,172,526	1,072,061	3,109,313	2,598,554	24,430	0	1,074,276	0.0
1977	5,185,216	2,592,608	1,027,560	1,543,805	655,566	61,549	331,688	1,030,928	32.2
1978	9,095,876	4,547,938	1,588,596	3,446,854	3,109,476	51,966	0	1,594,210	0.0
1979	6,343,929	3,171,964	849,510	2,130,684	2,058,992	-68,421	0	854,506	0.0
1980	8,072,668	4,036,334	1,486,842	2,722,476	1,903,441	14,077	0	1,499,104	0.0
1981	10,746,836	5,373,418	2,166,432	4,048,882	2,999,625	86,069	0	2,177,275	0.0
1982	7,769,182	3,884,591	1,801,810	2,511,821	1,865,465	-255,289	0	1,803,689	0.0
1983	6,074,677	3,037,339	1,080,956	2,036,851	1,108,896	-161,056	52,647	1,226,412	4.3
1984	5,267,347	2,633,673	774,199	1,571,219	781,686	-67,366	348,135	794,669	43.8
1985	6,626,453	3,313,226	1,150,578	1,795,172	1,253,227	73,296	191,532	1,161,005	16.5
1986	9,559,540	4,779,770	2,205,181	2,956,461	2,184,058	240,356	0	2,220,813	0.0
1987	6,545,001	3,272,501	1,172,173	2,029,824	1,433,674	10,554	0	1,153,489	0.0
1988	5,420,200	2,710,100	887,257	1,758,812	665,679	-186,716	472,324	898,076	52.6
1989	7,559,263	3,779,631	1,418,753	2,132,353	1,609,323	-140,684	178,639	1,466,145	12.2
1990	10,717,293	5,358,647	2,656,782	3,552,991	2,612,679	-82,612	0	2,663,777	0.0
1991	10,357,100	5,178,550	1,799,815	3,587,467	3,015,179	111,889	0	1,840,483	0.0
1992	7,167,462	3,583,731	1,470,446	2,590,124	946,935	25,035	21,638	1,536,264	1.4
1993	11,490,152	5,745,076	2,100,649	4,221,757	3,925,587	18,791	0	2,134,214	0.0
1994	7,159,533	3,579,766	1,454,141	2,344,389	1,893,153	-13,428	0	1,465,239	0.0
1995	12,954,855	6,477,428	1,896,513	3,667,395	4,433,745	-2,620	0	1,962,107	0.0
Average	8,185,887	4,092,944	1,483,235	2,707,251	2,167,348	-17,068	76,029	1,506,871	7.8

As indicated in columns 8 and 10, Table 10, in 14 of the 21 years between 1975 and 1995 apportionment could have been met fully by the flow contributed from the Bow and Oldman River basins, with absolutely no contribution from the Red Deer River. In the remaining seven years, flow contributions from the Red Deer River basin were required to meet apportionment, although these contributions were generally significantly less than 50% of the Red Deer natural flow. As further indicated in column 10, Table 10, there was only one year (1988) in which the Red Deer would have been required to contribute more than 50% of its natural flow (52.6% or about 9,000 dam^3 above 50%) in order to ensure that apportionment was met. In this year, the natural flow of the Oldman River basin was only 57.1% of its long term average, while apportionable flow (natural flow less U.S. diversions) was at only 54.1% of the long term average. Based on the foregoing analysis, it would appear that development within the Red Deer basin, during the 1975 to 1995 period, was not constrained by it being required to contribute a disproportionate volume of its natural flow to apportionment to offset consumption in the Bow and/or Oldman basins. However, it is noted that during this period the irrigation district, which derive their irrigation requirements from the Bow and Oldman, were not utilizing their full allocations. As such, the situation may change in the future if irrigation districts move towards a higher level of utilization by increasing diversions and reducing return flows.

8 SUMMARY

The South Saskatchewan River, immediately downstream of the Alberta-Saskatchewan boundary, receives water from four major sub-basin areas: the Red Deer, Bow, Oldman, and the Lower South Saskatchewan River sub-basins. The headwaters of the Red Deer and Bow Rivers are located entirely in the Alberta portion of the eastern face of the Rocky Mountains, while the Oldman River receives flow from the Waterton, Belly, and St. Mary Rivers, which have their headwaters in Montana.

The sharing of waters of the South Saskatchewan River with other jurisdictions is governed by two Agreements. The 1909 Boundary Waters Treaty between Great Britain and the United States of America (as stipulated by the 1921 Order of the International Joint Commission - IJC), outlines the division of waters of the St. Mary River, a tributary of the Oldman River. The 1969 Master Agreement On Apportionment outlines the division of waters between Alberta and Saskatchewan of eastward flowing interprovincial streams, including the South Saskatchewan River.

This report examined the recorded and naturalized flows throughout the system to evaluate the relative contribution of each of the sub-basins to the water-sharing agreements and to identify potential trends in their relative contributions.

The findings of this report are summarized as follows:

1. The South Saskatchewan River at the confluence with the Red Deer River has a mean annual flow of 8,399,000 dam^3. The mean annual flow is comprised of 1,507,000 dam^3 (17.9%) originating in the Red Deer basin, 3,665,000 dam^3 (43.6%) originating in the Bow basin, 3,191,000 dam^3 (38%) originating in the Oldman basin, and about 36,500 dam^3 (0.4%) that originate in the Lower South Saskatchewan basin.
2. The South Saskatchewan River and its tributaries are subject to two water-sharing agreements, the 1909 Boundary Waters Treaty which entitles the U.S to 25% of the flow in the St. Mary River for flows less than 666 cfs and to 50% of the flow in excess of 666 cubic feet per second, and the 1969 Master Agreement On Apportionment which entitles Saskatchewan to approximately 50% of the "apportionable" flow (natural less U.S.

diversions) of the South Saskatchewan River below the confluence with the Red Deer River.

3. Under the 1909 Boundary Treaty, the U.S. has diverted a mean annual volume of 210,000 dam^3 from the St. Mary River, or 7.3% of the natural flow of the Oldman River basin. During dry years, the U.S. diversions are in the order of 10% to 12% of the natural flow of the Oldman River basin. The U.S. diversions are currently less than the U.S. entitlements and will increase if the U.S. implements improvements to their storage and/or diversion infrastructure.

4. During the 21-year period analyzed, Alberta, on average, has passed 75.5% of the apportionable flow to Saskatchewan rather than the 50% required under the Master Agreement on Apportionment. This represents a mean annual surplus delivery to Saskatchewan of about 2,246,000 dam^3. Even during extremely dry years, Alberta has had surplus deliveries that are greater than 400,000 dam^3. As such, the large percentage of the natural flow of the Red Deer River delivered to Saskatchewan appears to be due to the non-consumption and lack of major storage devices in the basin rather than due to policy requirements. This surplus delivery will be marginally reduced if current accounting procedures are modified to include minor diversions in Alberta. These surplus deliveries may increase further during extremely dry years as a result of recently implemented minimum flow requirements for the South Saskatchewan River through Medicine Hat as well as other reaches throughout the system.

5. The Red Deer basin has a mean annual flow of about 1,507,000 dam^3. This has varied from a low of about 794,000 dam^3 (52.8% of average) to a high of 2,664,000 dam^3 (177% of average). Under current apportionment computation procedures, the Red Deer basin passes a relatively constant 98.4% of the mean annual natural flow to Saskatchewan.

6. The Bow basin has a mean annual flow of about 3,665,000 dam^3. This has varied from a low of about 2,643,000 dam^3 (72.1% of average) to a high of 4,897,000 (133% of average), or a significantly less variable supply than either the Red Deer or the Oldman basin. Under current apportionment computation procedures, the Bow basin has passed an average of about 72.5% of the mean annual natural flow to Saskatchewan. This percentage has varied from a low of 57.5% in 1984 and 1988 to a high of 86.2% in 1975 and 1994.

7. The Oldman basin has a mean annual flow of about 3,191,000 dam^3. This has varied from a low of about 1,544,000 dam^3 (48.4% of average) to a high of 6,502,000 dam^3 (204% of average), as such it has a significantly more variable supply than the Red Deer or the Bow basin. Under current apportionment computation procedures, the Oldman River has passed an average of about 68.7% of its mean annual "apportionable" flow to Saskatchewan. This percentage has varied from a low of 41.2% in 1988 to a high of 91.8% in 1975. In addition to the 1969 Master Agreement, the flows of the St. Mary River, a major tributary of the Oldman River, are also subject to water-sharing under the 1909 Boundary Waters Treaty. Under this agreement, the U.S. has diverted a mean annual volume of about 210,000 dam^3, 7.3% of the natural flow of the Oldman basin. This diversion could increase if the U.S. implements improvements to its storage facilities or diversion canal. On average, the Oldman basin contributes 71.3 % of its natural flow towards meeting the requirements of the two water-sharing agreements. This percentage has varied from a low of 47.9% in 1988, a year in which natural flow was only 57% of average, to a high of 92% in 1975.

8. Development within the Red Deer basin, during the 1975 to 1995 period, was not constrained by it being required to contribute a disproportionate volume of its natural flow to apportionment to offset consumption in the Bow and/or Oldman basins. However, it is noted that during this period the irrigation districts, which derive their irrigation requirements from the Bow and Oldman, were not utilizing their full allocations. As such, the situation may change in the future if irrigation districts move towards a higher level of utilization by increasing diversions and/or reducing return flows.

9 RECOMMENDATIONS

1. It is recommended that a review be conducted to assess the relative impact and tradeoffs of fixed versus variable instream flows, which are linked to natural flow, for the South Saskatchewan River through Medicine Hat as well as other reaches throughout the system.

   Article 4A of the 1969 Master Agreement on Apportionment recognized prior allocations in Alberta by stating "Alberta shall be entitled in each year to consume, or to divert or store for its consumptive use a minimum of 2,100,000 acre-feet net depletion out of the flow of the watercourse known as the South Saskatchewan River even though its share for the said year ... would be less than 2,100,000 acre-feet net depletion, provided however Alberta shall not be entitled to so consume or divert or store for its consumptive use, more than one-half the natural flow ... if the effect thereof at any time would be to reduce the actual flow ... at the common boundary ... to less than 1500 cubic feet per second." Recently implemented minimum flow requirements for the South Saskatchewan River through Medicine Hat as well as other reaches throughout the system however may preclude Alberta's ability to make full use of its entitlements under this clause. As such, the relative impact of instream flows on Alberta's ability to utilize its share of the water of the South Saskatchewan River needs to be assessed.

2. The implementation of a policy that would require each sub-basin to contribute 50% of apportionable flow to apportionment each and every year is not recommended.

   During many years, all three sub-basins exhibited similar conditions in terms of above, below or near average conditions, although of differing magnitudes. However, in about 38% of the years (1975, 1976, 1978, 1982, 1986, 1989, 1992, and 1994) the three basins experienced different conditions, in that one or two sub-basins experienced near average or above average conditions while the other(s) experienced below average conditions.

   The 1969 Master Agreement on Apportionment intentionally established the South Saskatchewan River below the confluence with the Red Deer River as the point for apportionment, even though this site is in Saskatchewan. This point was selected as the point for apportionment so as to permit Alberta to meet Saskatchewan's entitlements using any combination of flow from the three sub-basins it desired, thereby providing Alberta with added flexibility in managing its share of the flow of the South Saskatchewan River. If Alberta were to implement a policy that would require each sub-basin to contribute 50% of its annual flow to apportionment, regardless of sub-basin conditions, Alberta's water management flexibility would be significantly compromised and in fact could create a situation in which large surplus deliveries are being made to Saskatchewan while one or more of the sub-basins are experiencing a severe shortage.

APPENDIX A

INTERPRETATION OF
ALBERTA AND SASKATCHEWAN'S ENTITLEMENTS UNDER THE
MASTER AGREEMENT ON APPORTIONMENT

INTERPRETATION OF MASTER AGREEMENT ON APPORTIONMENT FOR THE SOUTH SASKATCHEWN RIVER

The Master Agreement for the South Saskatchewan is based on the 'apportionable volume" (the natural flow less U.S. diversions). Alberta's entitlement (allowable depletions) during a Calendar year is based on the apportionable volume provided it meets certain flow rate conditions at the interprovincial boundary. Alberta's entitlement of the apportionable volume and the flow rate conditions may be summarized as follows:

Zone	Apportionable Annual Flow Volume (dam^3)	Alberta Volume Entitlement (dam^3)	Saskatchewan Minimum Volume Entitlement	Flow Condition
1	0 to 2,680,000	50% of Apportionable volume	50 % of Apportionable volume	Alberta must pass the lesser of 50% of the natural flow rate or 42.8 m^3/s (1500 cfs)
2 a	2,680,000 to 3,930,000	Apportionable volume minus Sask. entitlement of 1,340,000 dam^3.	1,340,000 dam^3	To take more than 50%, of volume, Alberta must maintain a daily minimum flow rate of 42.8 m^3/s (1500 cfs) throughout the year. If minimum flow rate is not maintained at all times see 2b.
2b	2,680,000 to 3,930,000	50 % of Apportionable volume	50 % of Apportionable volume	Alberta must pass the lesser of 50% of the natural flow rate or 42.8 m^3/s (1500 cfs)
3a	3,930,000 to 5,180,000	2,590,000 dam^3	Apportionable volume minus Alberta entitlement of 2,590,000 dam^3.	To take more than 50% of volume, Alberta must maintain a daily minimum flow rate of 42.8 m^3/s (1500 cfs) throughout the year. If minimum flow rate is not maintained at all times see 3b.
3b	3,930,000 to 5,180,000	50 % of Apportionable volume	50 % of Apportionable volume	Alberta must pass the lesser of 50% of the natural flow rate or 42.8 m^3/s (1500 cfs)
4	5,180,000 or greater	50 % of Apportionable volume	50 % of Apportionable volume	Alberta must pass the lesser of 50% of the natural flow rate or 42.8 m^3/s (1500 cfs)

Implications of Operating Procedures on Alberta's Entitlements

As indicated in the above table, for apportionable volumes less than 2,680,000 dam^3 or greater than 5,180,000 dam^3, Saskatchewan is entitled to 50% of the volume regardless as to whether Alberta maintains a flow rate equal to 50% of natural or 42.5 cms or at its discretion alternates between the two.

For apportionable volumes between 2,680,000 dam^3 and 5,180,000 dam^3, Alberta's volume entitlement can be significantly impacted by the flow rate it maintains at the interprovincial boundary as demonstrated in the two following examples.

Example 1: Apportionable flow is 3,700,000 dam^3

a) If Alberta maintains a minimum flow of at least 1,500-cfs at the Interprovincial Boundary throughout the year.

   Then:
   Based on "2a" Alberta would be entitled to consume up 2,360,000 dam^3 (3,700,000 minus Saskatchewan's entitlement of 1,340,000 dam^3).

b) If Alberta **does not** maintain a minimum flow of at least 1,500-cfs at the interprovincial boundary throughout the year.

   Then:
   Based on "2b" Alberta would be entitled to consume only 50% of the apportionable flow or 1,850,000 dam^3.

Impact
By not maintaining a minimum flow of 1500 cfs at the interprovincial boundary, Alberta's entitlement is reduced by 510,000 dam^3 [2,360,000 dam^3 under example 1(a) versus 1,850,000 dam^3 under example 1(b)].

Example 2: Apportionable flow is 4,600,000 dam^3.

(a) If Alberta maintains a minimum flow of at least 1,500-cfs at the interprovincial boundary throughout the year.
   Then:
   Based on "3a" Alberta would be entitled to consume up to 2,590,000 dam^3.

(b) If Alberta **does not** maintain a minimum flow of at least 1,500-cfs at the interprovincial boundary throughout the year.
   Then:
   Based on "3b" Alberta would be entitled to consume only 50% of the apportionable flow or 2,300,000 dam^3.

Impact
By not maintaining a minimum flow of 1500 cfs at the interprovincial boundary, Alberta's entitlement is reduced by 290,000 dam^3 [2,590,000 dam^3 under example 2(a) versus 2,300,000 dam^3 under example 2(b)].